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P. 8, line 5, for 14-jugo-pinnata read 7-14-jugo-pinnata.
P. 16, lines 12 and 13 from below, for K. & S. read E. & K.
P. 16, line 17, for K. & S. read E. & K.
P. 22, line 16 from below, for K. & S. read E. & K.
P. 76, line 8 from below, for Ceidomya read Cecidomya.
P. 79, line 11 from below, for ataviem read atavism.
P. 135, line 2 from below, for E. M. Berry read E. W. Berry.
P. 203, over legend insert cut from p. 205.
P. 205, over legend insert cut from p. 203.
P. 218, line 2 from below, for Pflanzenatomie read Pflanzenanatomie.
P. 229, line 10 from below, for ulva read Ulva.
P. 284, line 10 from below, for Craspedorachis read Craspedorhachis.
P. 297, line 22, for ovulate read ovular.

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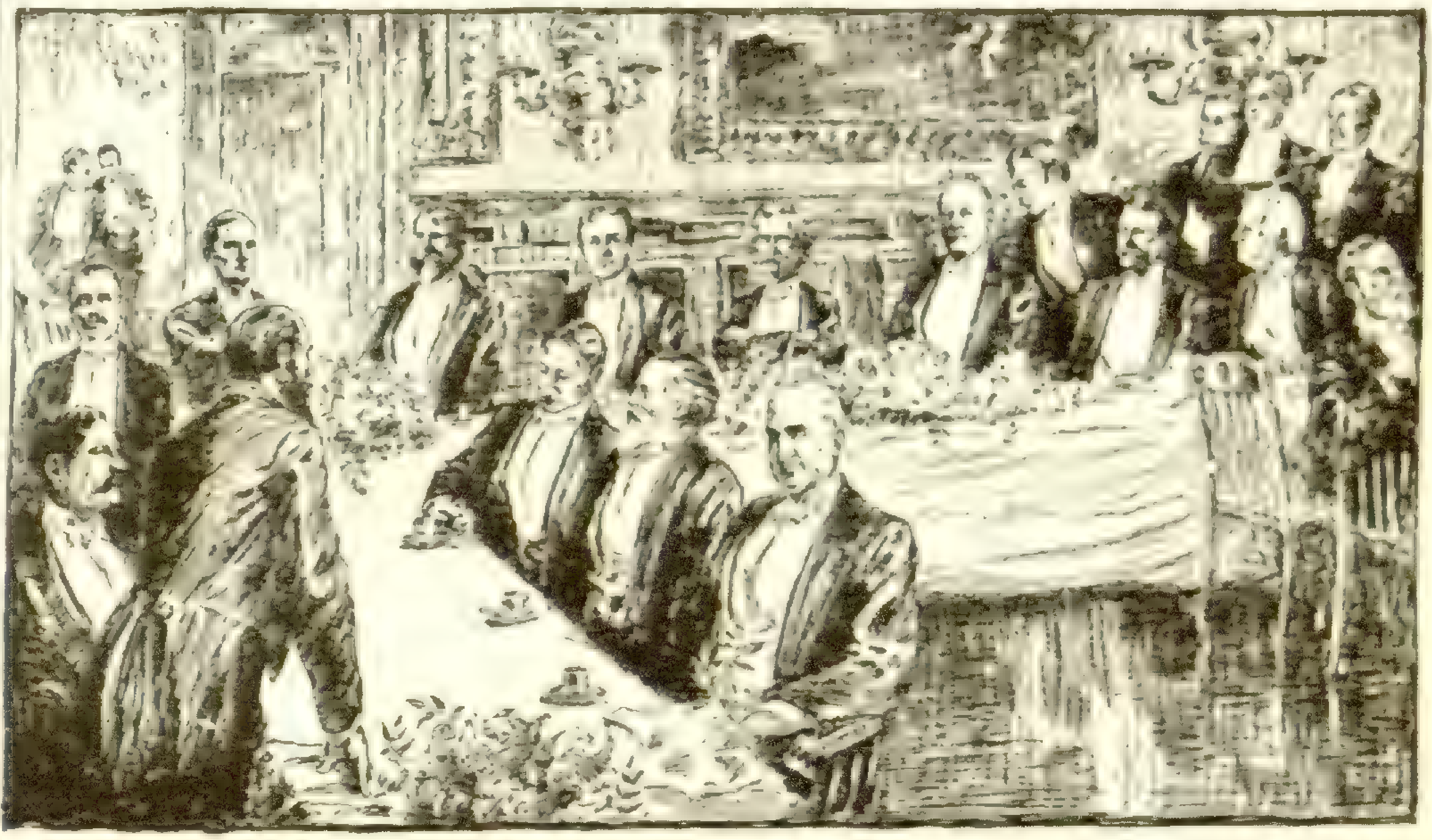

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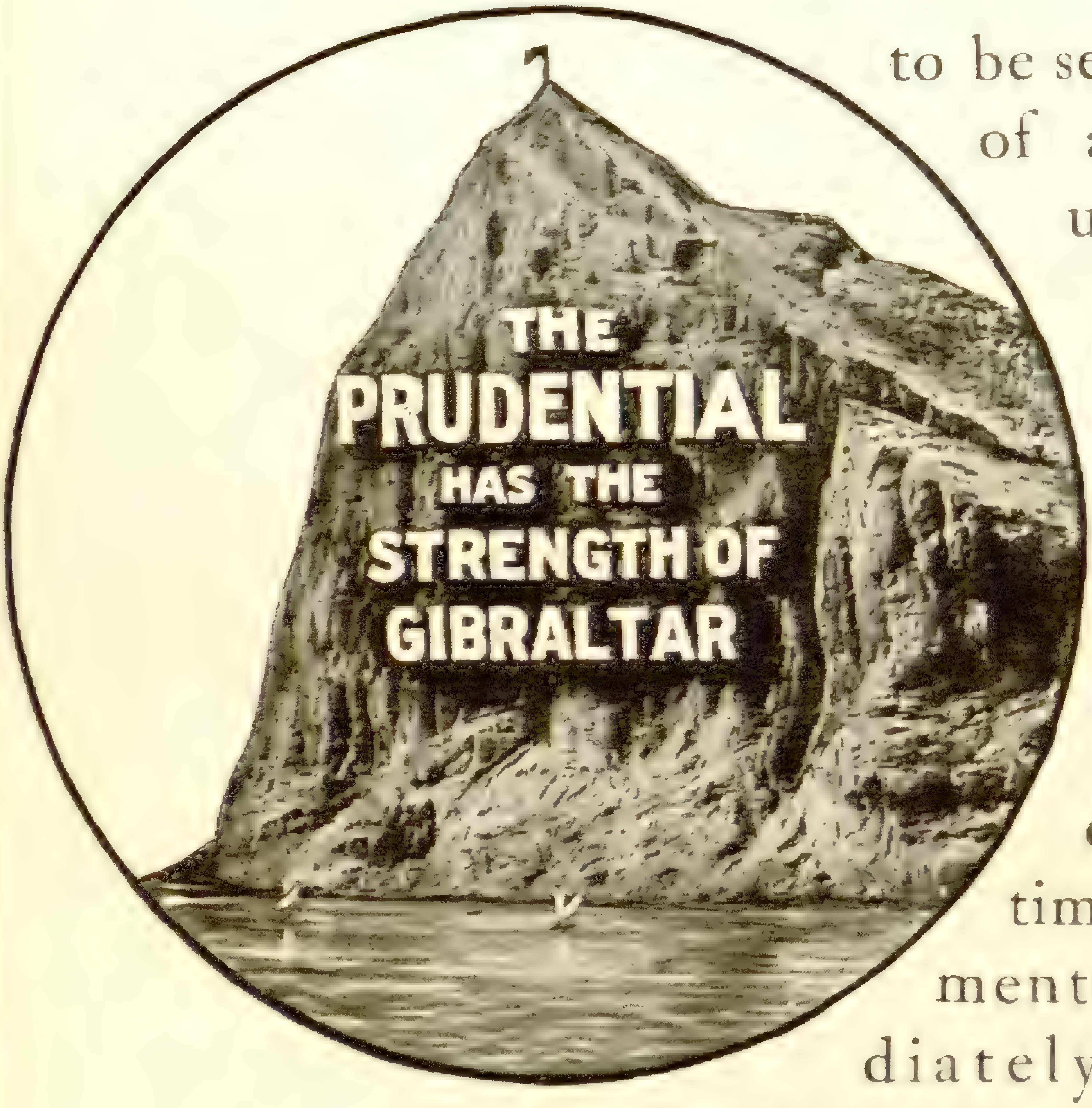

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JANUARY, 1903

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JOHN DONNELL SMITH.

(WITH PLATE I)

Clusia Salvinii Donn. Sm. (§ ANANDROGYNE Planch. et Triana).—Folia crassa oblongo-obovata apice rotunda in petiolum marginatum attenuata, nervis lateralibus late patentibus remotiusculis. Inflorescentia subspicata decussata quinqueflora, pedicellis brevissimis basi bracteatis, floribus ipsis ebracteatis. Sepala 4 decussata. Petala 5 obovata sepalis parum majora. Antherae filamentis 3-plo longiores. Staminodia 5 libera e basi semiorbiculari dentiformia. Capsula globosa 5-locularis, seminibus in loculo quovis numerosis leviter ascendentibus.

Ramuli subteretes di-trichotomi. Folia 11-17^{cm} longa 5.5-9^{cm} lata margine revoluta, costa subtus tantum prominente infra apicem folii desinente, nervis angulo 60° a costa abeuntibus 3-4^{mm} inter se distantibus, nervo collectivo submarginali, venulis supra tantum manifestis, petiolis 1-1.5^{cm} longis. Pedunculus cum axe quadrangularis, pedicellis vix 2^{mm} longis, bracteis ovatis 5^{mm} longis. Sepala late suborbicularia 7-9^{mm} longa. Stamina 45-50 circiter 7^{mm} longa pistilli rudimentum includentia, receptaculo convexo 4^{mm} diam. metiente. Capsula 15-18^{mm} crassa basi sepalis paullo auctis et petalorum vestigiis cincta staminodiis 1.5^{mm} altis instructa, stylis 3-4^{mm} longis subconnatis, stigmatibus obovatis 2-3^{mm} longis in conum conniventibus, seminibus imbricatis circiter 20 plerumque abortivis. Flores feminini deficiunt.

Volcán de Fuego, Depart. Zacatepéquez, Guat., alt. 2600^{m}, Oct. 1873, *Osbert Salvin*.—Volcán de Fuego, Guat., alt. 2300^{m}, Mart. 1892, *Donn. Sm.*, n. 2530 ex Pl. Guat. &c., quas ed. Donn. Sm.

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[1] Continued from BOT. GAZ. 33:262. 1902.

Mo. Bot. Garden
1904.

Melochia Bernoulliana Donn. Sm. (§ MOUGEOTIA K. Schum. in Mart. Fl. Bras. **12^3** : 35).—Folia praeter nervos glabra magna lanceolato-ovata graciliter attenuata basi rotundata vel subcordata dupliciter serrata. Flores nunc in axillis fasciculati nunc in thyrsos axillares et terminales foliis plus minus breviores foliis reductis deciduis bracteatos dispositi. Calyx petalis triente brevior usque ad duas partes partitus, segmentis ovatis acuminatis. Tubus stamineus petalis bis superatus ultra medium fissus. Capsula breviter stipitata depresso-globosa calycem aequans profunde lobata.

Suffrutex $1\text{-}1.5^{m}$ altus, ramulis petiolis foliorum nervis inflorescentiae axibus calycibus capsulis minutissime stellulato-pubescentibus. Folia $8\text{-}13^{cm}$ longa $3\text{-}5^{cm}$ lata, nervis lateralibus praeter 1-2 utrinque basales inferiores breves parallelis utrinque 7-9, petiolis $1.5\text{-}3^{cm}$ longis ad apicem versus incrassulatis, stipulis cito deciduis. Pedicelli $2\text{-}7^{mm}$ longi. Calyx campanulatus 4^{mm} altus. Petala attenuato-oblanceolata 6^{mm} longa. Stamina 4^{mm} longa, filamentis liberis 1.75^{mm} longis, antheris 1^{mm} longis. Ovarium pilosum ovale 1^{mm} longum stylos liberos aequans vel eis dimidio brevius. Capsula pilis longis conspersa pentagona 4^{mm} longa, coccis loculicide indehiscentibus toto tergo dehiscentibus, seminibus glabris oblique lateque ovalibus 2.5^{mm} longis compressis.

Retalhuleu, Guat., 1877, *Bernoulli* et *Cario*, nn. 3112 et 3113.—Ad oras Río De Los Esclavos, Depart. Santa Rosa, Guat., alt. 800^{m}, Nov. 1892, *Heyde* et *Lux*, n. 4319 ex Pl. Guat. &c., quas ed. Donn. Sm.

Microsechium (?) compositum Donn. Sm.—Folia punctata supra scabriuscula subtus glabrescentia cordato-suborbicularia latiora quam longiora leviter obtuseque 5-7-lobata, margine denticulato. Inflorescentiae folia longe superantes, pedunculis simplicibus vel repetitus dichotomis, floribus 4-5-meris in racemulos dissitos confertis graciliter pedicellatis. Calycis tubus pateriformis 8-10-radiatus sub apice 8-10-foveolatus, dentibus minutis. Petala oblongo-ovata extus canescentia. Staminum filamenta gracilia usque ad medium coalita.

Altissime scandens. Folia membranacea subtus pallidiora cum sinu basilari subrectangulari $5\text{–}6^{cm}$ longo $3\text{–}4^{cm}$ lato adjecto $18\text{–}21^{cm}$ longa $22\text{–}26^{cm}$ lata, nervis in mucrones subulatos excurrentibus, petiolis glabrescentibus $10\text{–}16^{cm}$ longis. Cirrhi glabri elongati striati. Inflorescentiae cum pedunculis plerumque simplicibus $8\text{–}12^{cm}$ longis adjectis $35\text{-}50^{cm}$ longae, dichotomiis cirrhiferis, racemulis numerosissimis sessilibus vel pedunculatis multifloris, pedicellis $11\text{–}28^{mm}$ longis, floribus in sicc. intense viridibus plerumque pentameris

Calyx 5 ^{mm} latus, dentibus subulatis 2 ^{mm} longis. Petala patula intus puberula 5–6 ^{mm} longa 7-nervia. Staminum filamenta 5 ^{mm} longa supra medium radiata, antheris 4 vel saepius 5 suborbicularibus 1 ^{mm} longis bilocularibus, loculis flexuosis. Caules flores feminini fructus non suppetunt.— Hanc speciem solum ad folia et inflorescentias masculinas ex caule strictas constitutam Microsechio haud absque dubio adscripsi.

Malpais, Depart. Santa Rosa, Guat., alt. 1100 ^{m}, Sept. 1893, *Heyde* et *Lux*, n. 6146 ex Pl. Guat. &c., quas ed. Donn. Sm.

Psychotria anomothyrsa K. Schum. et Donn. Sm. (§ NOTOPLEURA Benth. in Oerst. Centralam. Rub. 37).— Folia maxima membranacea nitida oblanceolato- vel obovato-oblonga acuminata in petiolum longum complanatum attenuata. Pedunculi ex axillis alternis orti petiolis longiores, thyrsi ramis 2–3-nis, nunc semel vel bis dichotomis, nunc inferne trichotomis superne dichotomis, bracteolis oppositis alternatim floriferis, floribus minutis sessilibus secus axes binatim raro singulatim dissitis. Drupa pallida lineolis candidis farcta.

Suffrutex superne subherbacea simplex glabrescens hinc inde lineolatus. Folia subtus pallidiora 25–35 ^{cm} longa 9–17 ^{cm} lata, nervis lateralibus inter se 1–2 ^{cm} distantibus utrinque 9–14, petiolis marginatis 3–8 ^{cm} longis, stipulis deciduis. Pedunculi 6–12 ^{cm} longi sicut inflorescentiae axes complanati et marginati. Thyrsi cinereo-puberuli pyramidales vel oblongi 4–12 ^{cm} longi, axibus divaricatis nonnunquam recurvatis, bracteolis amplexicaulibus ovatis 1–2 ^{mm} longis. Calyx obpyramidatus 1.25 ^{mm} altus, dentibus obtusiusculis. Corolla glabra lineolata 4–5 ^{mm} longa usque ad tertiam vel quartam partem lobata, lobis ovatis. Stamina paullo infra fauces barbatas vel imberbes inserta, filamentis brevissimis. Drupa obovato-ovalis 5 ^{mm} longa 3.5 ^{mm} lata, endocarpio tenuissimo, pyrenis dorso profunde 4-sulcatis facie ventrali planis laevibus.— *P. uliginosae* Sw. proxima inflorescentiis anomalis insigniter distinguitur.

Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350 ^{m}, Dec. 1900, *von Tuerckheim*, n. 7909 ex Pl. Guat. &c., quas ed. Donn. Sm.— Prope Tarapoto, Peruvia Orientalis, 1855-6, *Spruce* sine numero.— El Recreo, Prov. Manabi, Ecuador, *Eggers*, n. 15.119. (Exemplaria Eggersiana thyrsos magis elongatos optime evolutos praebent.)

Rudgea ceratopetala Donn. Sm.— Folia elliptica vel oblongo-elliptica utrinque praesertim sursum longe contracto-acuminata, petiolis brevissimis, stipulis breviter oblongis apice aculeoligeris. Cyma longe pedunculata foliis paullo vel dimidio brevior laxiflora, floribus pubescentibus, lateralibus graciliter pedicellatis.

Corolla calyce 4-plo longior usque ad medium paene fissa, tubo cylindrico ad medium staminigero et ibidem tantum piloso, segmentis patentibus linearibus apice inflexo-cornutis.

Praeter flores glabra. Rami dichotomi. Folia chartacea 11–16 ^{cm} longa 4–6.5 ^{cm} lata, nervis lateralibus subtus conspicuis utrinque 8–10, petiolis 2–3.5 ^{mm} longis. Stipulae 3 ^{mm} longae aculeis cartilagineis pluribus incisae. Pedunculi 4–5 ^{cm} longi, cymis 3–5 ^{cm} altis 6–7 ^{cm} latis, ramis oppositis 2-jugis divaricatis bis dichotomis, floribus 5-meris in dichotomiis sessilibus, cymulis trifloris, pedicellis lateralibus subdivaricatis 7–9 ^{mm} longis, bracteis minutis triangularibus integris. Calycis 3 ^{mm} alti limbus in sicc. pallescens cupulatus denticulatus tubum breviter cylindricum aequans. Corolla in sicc. fusca, segmentis 5 ^{mm} longis 3-nerviis cornu 1 ^{mm} longo appendiculatis. Antherae inclusae 3 ^{mm} longae filamentis 3-plo longiores. Stylus pubescens cum stigmatibus 2 ^{mm} longis adjectis corolla paullo brevior. Baccae ignotae. —Ad *R. micrantham* Muell. Arg. inflorescentia et calyce accedens foliis pedunculis corollis aliisque notis tamen recedit.

Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350 ^{m}, 1901, *von Tuerckheim*, n. 7904 ex Pl. Guat. &c., quas ed. Donn. Sm.

Eupatorium hypomalacum Robinson.— Frutescens vel suffrutescens; ramis cortice griseo tectis subancipitibus, internodiis in parte superiore plus minusve sexangularibus pilis perbrevibus incurvatis vestitis; foliis oppositis lanceolatis integris vel obscure remoteque denticulatis acuminatis basi acutis penninervatis tenuibus supra laete viridibus in venulis sparse pubescentibus subtus pallidioribus molliter tomentosis et glanduliferis 12–14 ^{cm} longis 3.5–4.5 ^{cm} latis; petiolis subteretibus fulvotomentulosis 1.5 ^{cm} longis; thyrso pyramidato 1 ^{dm} longo; bracteolis oppositis perbrevibus griseis basi crassiusculis; capitulis parvis 8–10-floris, graciliter pedicellatis; squamis involucri paucis (10–12) valde inaequalibus pallide viridibus striatis sparse pubescentibus acutis, exterioribus lanceolatis, interioribus oblongis 4–5 ^{mm} longis; corollis albis glabris 2.4 ^{mm} longis, faucibus teretibus tubum proprium perbrevem superantibus, dentibus 5 brevissimis deltoideis; achenio 2.2 ^{mm} longo acute angulato in angulis sursum hispidulo; pappi setis subaequalibus circa 25 albis simplicibus.

This species shows a general affinity to *E. pinabetense* Robinson, *E. Tuerckheimii* Klatt, and *E. pansamalense* Robinson, although it is not very close to any one of these species.

Los Verdes, Depart. Amatitlán, Guat., alt. 1100^{m}, Aug. 1893, *Heyde* et *Lux*, n. 6157 ex Pl. Guat. &c., quas ed. Donn. Sm.

Sideroxylon uniloculare Donn. Sm.—Folia glabra maxima oblongo- vel obovato-elliptica cuspidato-acuminata basi cuneata, nervis lateralibus parallelis remotis utrinque conspicuis, petiolis brevibus. Calycis segmenta basi coalita jam in alabastro aperta. Corollae calyce dimidio longioris lobi orbiculares. Stamina cum staminodiis eis paullo longioribus lanceolatis sub apice tubi affixa, antheris subsessilibus lateraliter dehiscentibus. Ovarium depresso-obpyramidatum 1-loculare, ovulo unico nunc pendulo nunc lateraliter affixo.

Folia coriacea 13–21^{cm} longa 6–9^{cm} lata, cuspide obtusiuscula, nervis lateralibus inter se 1–1.5^{cm} distantibus utrinque 12–14 subtus validis, venis minutissime reticulatis subtus prominulis, petiolis canaliculatis 8-15 ^{mm} longis. Pedicelli ferrugineo-pubescentes dense fasciculati 7^{mm} longi, floribus 5-meris. Calyx ferrugineo-pubescens 2^{mm} altus usque ad duas partes fissus, segmentis ovatis consimilibus. Corolla glabra, lobis tubum bis superantibus margine erosis. Antherae ovatae 0.5^{mm} longae pilis albidis conspersae. Staminodia 1^{mm} longa subintegra. Ovarium pubescens 0.75^{mm} altum 1.5^{mm} latum, stylo subulato 0.5^{mm} longo, stigmate parvo integro. Bacca mihi non visa.

Secus Río De Las Vueltas, Tucurrique, Costa Rica, alt. 635^{m}, Maj. 1899, *Tonduz*, n. 13358 herb. nat. Cost.

Styrax polyneurus Perk.—Arbor, rami subteretes, juniores fusco-tomentosi, adulti demum glabrescentes, folia 1-1.5^{cm} longe petiolata, lanceolata vel obovato-lanceolata vel obovato-oblonga, 12–9^{cm} longa, 4–2.25^{cm} lata, basi in petiolum a latere compressum sensim cuneato-angustata, apice acuta vel breviter late acuminata, apice ipso acutiusculo, papyracea vel subchartacea, integra, supra juniora hinc inde pilos stellatos minutos gerentia, adulta glabra, subtus pilis albidis lepidotis stellatis tomentosa, nervis 6–9-jugis venisque supra vix, subtus valde prominentibus, venis validioribus inter sese parallelis rectangulariter costae insedentibus, omnibus dense reticulatis; flores ignoti; fructus ovoideus, 7^{mm} longus, 3-4^{mm} crassus, breviter mucronatus, lepidibus argenteis dense tectis.—Ab incolis *Resina* dicitur.

This species is closely related to *S. myristicifolius* Perk. in Bot. Jahrb. **31**: 481, but differs from it in the form and nervature of the leaf, and in the color and shape of the hairs on the under surface. It is very noticeable that the fruit of *S. polyneurus* is much smaller than that of *S. myristicifolius*, and that it is densely covered with silvery scales.

In silvis ad Copey, Cost., alt. 1800^{m}, Febr. 1898, *Tonduz* n. 11744 herb. nat. Cost.

Dianthera sulfurea Donn. Sm. (§ JACOBINIOIDEAE, Ser. E. Benth. et Hook.)—Folia brevissime petiolata ovato-lanceolata in apicem obtusiusculum producta basi rotunda vel subcordata praeter nervos venasque glabrescentia. Pedunculi axillares foliis 3–4-plo breviores, spica subcapituliformi triflora, floribus pedunculum paullo superantibus. Calyx bracteolis aequilongus, segmentis 4 lanceolato-linearibus. Corolla flava densissime longeque pilosa usque ad medium fere bilabiata, labio postico integro. Antherae sagittatae, connectivo triangulari.

Suffrutex 1–2-metralis, ramis brachiatis declinatis teretibus unifariam pubescentibus. Folia $6–9^{cm}$ longa $2–3.5^{cm}$ lata basi saepe inaequalia supra cystolithiis dense atro-lineolata, petiolis pubescentibus $2–3^{mm}$ longis. Pedunculi pilis conspersi $15–25^{mm}$ longi, bracteis 5^{mm} et bracteolis 8^{mm} longis attenuato-linearibus glandulari-pilosis. Calycis segmenta basi breviter coalita pilosula. Corolla $26–28^{mm}$ longa, tubo recto superne paullo ampliato, labio postico erecto, antici paullo brevioris lobulis $2–3^{mm}$ longis. Stamina labium posticum aequantia, antheris 3^{mm} longis basi 2^{mm} latis, loculis oblongis divergentibus, altero breviore paululum inferius posito. Discus cupularis. Ovarium oblongum 2.5^{mm} altum 4-ovulatum, stylo 28^{mm} longo. Capsula ignota.—*D. latifoliae* Benth. et Hook. proxima differt insigniter corollae colore.

Cerro Redondo, Depart. Santa Rosa, Guat., alt. 1200^{m}, Sept. 1893, *Heyde* et *Lux*, n. 6215 ex Pl. Guat. &c., quas ed. Donn. Sm.

Ocotea tenera Mez et Donn. Sm.—Foliis submembranaceis, glaberrimis, anguste vel bene ellipticis, basi acutis apice elegantissime acuminatis, penninervibus, utrinque sed praesertim subtus laxe prominulo-reticulatis; inflorescentiis tenerrimis, laxis squarrosisque, ♂ tripinnatim, ♀ bipinnatim paniculatis, quam folia brevioribus; floribus subdioicis, glaberrimis; tubo perianthii brevissimo; filamentis glabris vel pilis perpaucis, brevissimis praeditis, ♂ quam antherae subrectangulares, anguste rotundatae paullo longioribus, ♀ paullo brevioribus; staminodiis nullis vel minutissimis, stipitiformibus; ovario glabro, stylo crassiusculo, breviore.

Ramuli gracillimi, glaberrimi, cortice esipido, mucoso. Folia petiolis vix ultra 10^{mm} longis, tenuibus stipitata, sparsa vel subdisticha, utrinque sed praesertim subtus nitidula, plus minus 120^{mm} longa, 40^{mm} lata, sicca nunc manifestius nunc obscurius nigrescentia et margine (saepius non nisi minute) crispulata. Inflorescentiae ♂ submultiflorae, ♀ pauciflorae, pedicellis gracillimis usque ad 5^{mm} longis, bracteis deciduis. Flores 2–2.5^{mm} longi, limbi segmentis aequalibus, e late ovato ♂ longius ♀ breviter acutis, constanter punctulis numerosissimis mucosis in sicco prominulis aqua mollitis sub lente optime pellucidis insignibus. Glandulae florales filamentis ser. III basi affixae, e minoribus, globosae. Ovarium floribus ♂ quoque haud male evolutum. Bacca ellipsoidea, plus minus 22^{mm} longa, 11^{mm} diam. metiens, cupulae parvae, simplicimarginatae, planiusculae, sensim in pedicellum clavatim incrassatum transeunti insidens, inflorescentiae cuique fructiferae singula evoluta.

Turrialba, Prov. Cartago, Cost., alt. 570^{m}, Jun. 1895, *Tonduz*, n. 8330 herb. nat. Cost.—In silvis prope Shirores, Talamanca, Cost., alt. 100^{m}, Febr. 1895, *Pittier* et *Tonduz*, n. 9184 herb. nat. Cost.— La Colombiana, Llanuras de Santa Clara, Cost., alt. 200^{m}, Jun. 1899, *Pittier*, n. 7607 ex Pl. Guat. &c., quas ed. Donn. Sm. (n. 13396 herb. nat. Cost.)

Croton pyramidalis Donn. Sm. (§ EUCROTON Muell. Arg.)—Folia oblongo-ovata acuminata cordata abbreviato-3–5-nervia basi biglandulosa discoloria supra sparsim subtus densissime ciliatolepidota. Racemi in paniculas unisexuales axillares terminalesque amplas dispositi, masculini floribundi, feminini sparsius floriferi, floribus solitariis, femininis brevius pedicellatis. Floris ♂ petala oblonga, stamina 15. Floris ♀ petala nulla, styli 4-fidi.

Arbor. Indumentum lepidibus ciliato-radiatis quasi tomentulosum in ramulis petiolis foliorum nervis paniculis calycibus ferruginascens. Folia 10–17^{cm} longa 5–9^{cm} lata integra subtus canosa, petiolis 3.5–5^{cm} longis, stipulis subulatis 3–4^{mm} longis deciduis. Paniculae foliis reductis inferne suffultae subpyramidales 11–18^{cm} longae, bracteolis subulatis 3–4^{mm} longis deciduis. Floris ♂ calyx campanulatus 4^{mm} altus pedicellum subaequans, glandulis obovatis crassis, segmentis breviter coalitis ovatis intus glabris, petala calyci aequilonga extus cano-villosa, stamina praeter basin glabra 7^{mm} longa, antheris lineari-ellipticis 2^{mm} longis, receptaculum cano-villosum. Floris ♀ calyx mari similis pedicello bis longior, glandulis inconspicuis, ovarium lepidotum hemisphericum 2.5^{mm} latum, stylis lepidotis crassis 1.5^{mm} longis apice ramos 4 glabros simplices 2^{mm} longos ferentibus, capsula globosa 5.5-diametralis, seminibus nitidis atris rugulosis.—Ad *C. paniculatum* Muell. Arg. nonnullis notis accedit, paniculis unisexualibus (an dioicis ?) tamen recedit; hanc ob rem affinitas systematica perincerta est.

Ad oras Río Dolores in fundo Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350^{m}, Jul. 1901, *von Tuerckheim*, n. 7974 ex Pl. Guat. &c., quas ed. Donn Sm.— Eandem plantam, ut videtur, a cl. E. P. Johnson in Yucatan vel Tabasco sub n. 118 lectam in Herb. Kew. inveni.

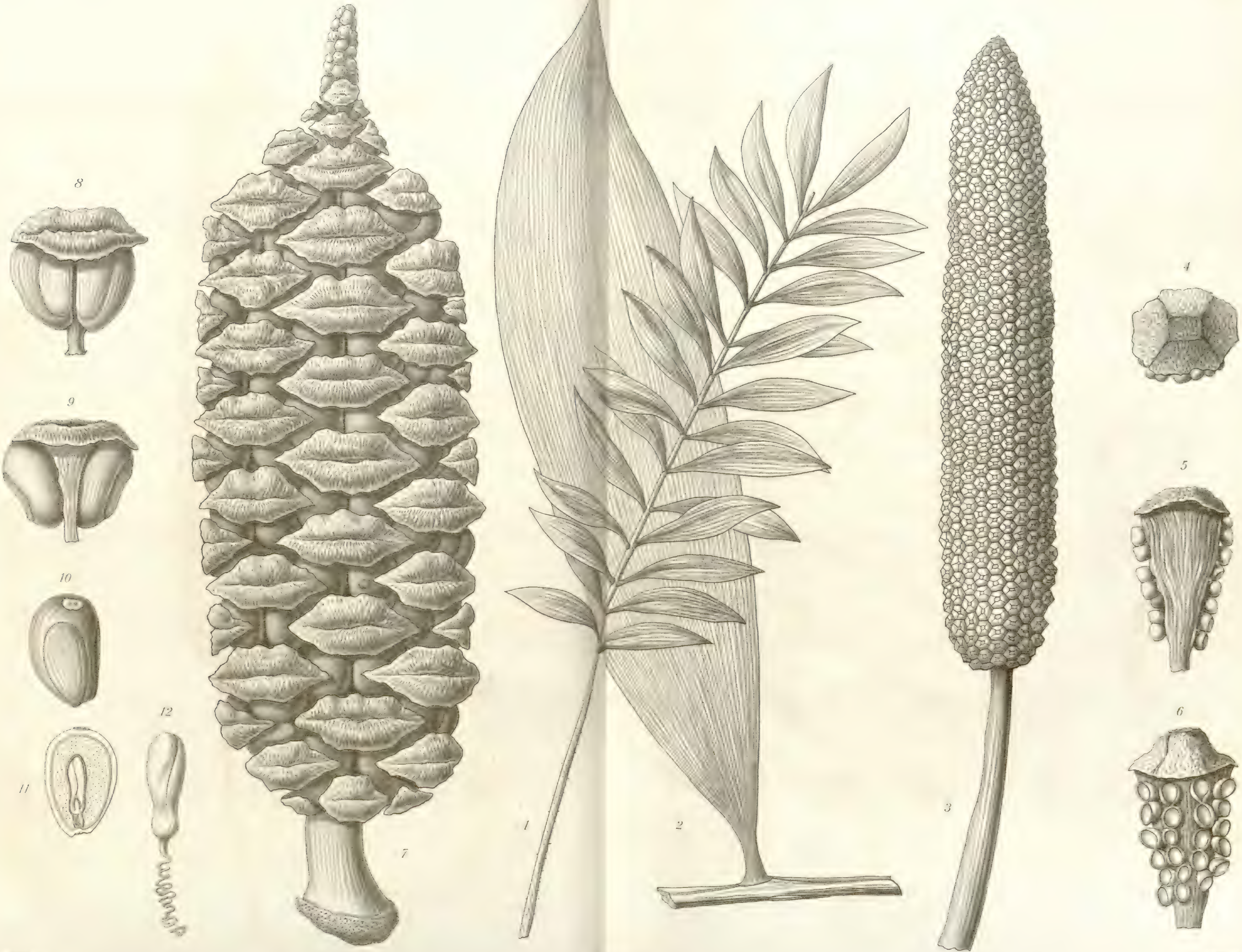
Zamia Tuerckheimii Donn. Sm.— Folia glabra 14-jugo-pinnata, rhachi petiolum sparsim minuteque aculeatum bis superante ultra foliola graciliter producta, foliolis suboppositis oblanceolatis abrupte breviterque acuminatis in basin perangustam attenuatis integerrimis, nervis in medio folioli 40 et ultra in basi circiter 8. Strobilus ♂ lineari-cylindricus pedunculo bis longior, staminibus tota facie inferiore praeter plagam mediam angustam loculigeris. Strobilus ♀ brevissime pedunculatus longe cuspidato-acuminatus, carpidiorum seriebus et verticalibus et horizontalibus circiter 9.

Truncus saxifragus primum pendens demum ascendens 1.5–3^{m} longus 2^{dm} crassus nonnunquam furcatus (De Tuerckheim in litt.). Folii rhachis trigona circiter 9^{dm} longa, internodiis 5–7^{cm} longis, mucrone terminali 1.5^{cm} longo, foliolis firmo-chartaceis supra nitidulis subtus pallidioribus 19–24^{cm} longis medio 4–5^{cm} basi 3^{mm} latis. Strobilus ♂ 14^{cm} longus 2.5^{cm} crassus apiculatus, peltis cano-farinosis truncato-pyramidatis subaequaliter hexagonis, staminum seriebus verticalibus circiter 24, horizontalibus circiter 36, loculis 18–26 globosis discretis vel binatim cohaerentibus. Strobilus ♀ pedunculo 2^{cm} longo sustentus 18^{cm} longus 6^{cm} crassus, cuspide peltis sterilibus adspersa tenuiter conica 3^{cm} longa, peltis cinereo-tomentulosis planis hexagonis bis et ultra latioribus quam longioribus. Semina coccinea obovoidea 2^{cm} longa 13^{mm} lata.— Monente Thiselton-Dyer, Hort. Bot. Reg. Kew, claro rectore, *Z. acuminatae* Oerst. ex Dyer in Hemsl. Biol. Centr.-Am., necnon *Z. Houtteanae* This.-Dyer, MS. in Herb. Kew, affinis; haec tamen foliolis falcatis vix acuminatis, illa foliolis paucioribus sensim tenuiterque acuminatis, utraque nervis minus crebris, diversa; utriusque strobili ignoti.

In praecipitiis saxosis udis umbrosis prope Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350^{m}, Jul. 1900, *von Tuerckheim*, n. 7786 ex. Pl. Guat. &c., quas ed. Donn. Sm.

EXPLANATION OF PLATE I.— FIG. 1, leaf, reduced to ⅛ natural size.— FIG. 2, leaflet, natural size.— FIG. 3, staminate strobile, natural size.— FIG. 4, vertical view of stamen, enlarged.— FIG. 5, upper side of stamen, enlarged. — FIG. 6, lower side of stamen, enlarged.— FIG. 7, strobile in fruit, natural size.— FIG. 8, lower side of carpidium, enlarged.— FIG. 9, upper side of carpidium, enlarged.— FIG. 10, seed, enlarged.— FIG. 11, vertical section of seed, enlarged.— FIG. 12, embryo, enlarged.

PLATE I.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ZAMIA TU HEIMII, Donn. Sm.

Guzmania Donnellsmithii Mez (§SCHLUMBERGERIA Morr.)—Foliis adultis dorso saltem lepidibus numerosissimis parvis pallidis conspersis; inflorescentia bipinnatim densiuscule panniculata e spicis breviter quidem sed tamen manifeste stipitatis, 3-floris composita; bracteis florigeris quam sepala basi breviter connata multo brevioribus; petalis tubulose erectis absque dubio alte connatis quam sepala vix ultra 5^{mm} longioribus.

Acaulis, florifera paullo ultra 0.3^{m} alta. Folia multa dense rosulata, basi in vaginam paullo ventricosam, ovalem, optime denseque lineis violaceis longitudinaliter striatam dilatata, non nisi imperfecte cognita verisimiliter in apicem acutum sensim angustata. Scapus foliis non nisi summis vaginaceis, stricte erectis, persensim acutissimis, internodia perlonge superantibus involutus et omnino celatus, erectus. Inflorescentia verisimiliter folia paullo superans, submultiflora, breviter thyrsoidea, mihi visa 110^{mm} longa, ex sicco pulchre rubens; axibus glabris; bracteis primariis amplis, ex ovato acuminatis, summis quam spicae axillares bene brevioribus, inferioribus eas longe superantibus; bracteis florigeris late ellipticis, rotundatis, haud carinatis, membranaceis, inferioribus ad 8^{mm} longis, 4^{mm} latis; spicis paullo laxiusculis bene quaquaverse florigeris, inferioribus pedunculis 5.6^{mm} longis crassiusculis nudis stipitatis. Flores subsessiles, 21^{mm} longi, tenues gracilesque, erecti; sepalis 16^{mm} longis, basi breviter aequaliterque connatis, explanatis fere lineari-ellipticis, apice rotundatis, haud carinatis. Petala usque ad 5^{mm} ab apice in tubum perfectum cylindricum connata, lobis ut videtur per anthesin erectis, ovatis, bene rotundatis. Stamina petalis breviora eorumque fauci inserta, filamentis apice brevissime tantum liberis, antheris 2.5^{mm} longis, sublinearibus, acutis. Ovarium ellipsoideum, stylo gracillimo, stigmatibus breviter clavatim contortis.—Species absque dubio ordinis e pulcherrimis hortulanisque quam maxime requirenda *G. Zahnii* Mez valde accedit, differt tamen, ne plura proferam, spicis paucifloris.

In silvis profundis Suerrensibus, Llanuras de Santa Clara, Cost., alt. 300^{m}, Febr. 1896, *Donn. Sm.*, n. 6824 ex Pl. Guat. &c., quas ed. *Donn. Sm.*

BALTIMORE, MD.

CULTURES OF UREDINEAE IN 1902.[1]

J. C ARTHUR.

THE present article forms the third of a series of reports by the author upon the cultures of plant rusts. The first one[2] covered the year 1899, the second[3] combined the years 1900 and 1901, and the third covers the year 1902. Like the preceding ones, the present report is devoted largely to the heteroecious grass and sedge rusts. The methods employed have already been described in connection with the previous reports.

The work was much more extended during the present season than had been possible in preceding years through the interest taken in it by the authorities of Purdue University, who generously defrayed the expense of additional assistance during the months of May and June, when the largest part of the work must be done. In this way it became possible to have the help for a time of Mr. Oliver P. Terry, an undergraduate of the university, and an unusually skilful manipulator. But the larger part of the testing with drop cultures and of the application of the spores to the plants throughout the whole of the busiest period was undertaken by Miss Julia Titus Emerson, of New York City, coming from the New York Botanical Garden, who showed great earnestness and rare judgment in carrying on the work.

During the present season 123 collections of material were employed, and 314 drop cultures were made from them to test the germinating condition of the spores. Out of these 23 collections refused to germinate, and were consequently useless. There were in all 327 plant cultures attempted, representing 43 species of rusts, and employing 102 species of hosts temporarily grown in pots in the greenhouse. In no case was success attained where definite clues derived from field observations were lacking.

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[1] Read before the Botanical Society of America, Washington, Jan. 1, 1903.

[2] BOT. GAZ. **29**: 268–276. April 1900.

[3] Jour. Mycology **8**: 51–56. June 1902.

Fourteen species were tried this year by the guessing method, no clues being known, and the following is a record of the failures, together with one instance, that of the Panicularia rust, where a seeming clue also failed. Teleutospores were employed in every case.

1. MELAMPSORA from *Populus deltoides* Marsh. was sown on *Larix europaea*, *Abies balsamea*, *Euonymus obovatus*, *Stylophorum diphyllum*, *Helianthus strumosus*, and *H. grosse-serratus*, with no infection.

2. MELAMPSORA on *Salix discolor* Muhl. was sown on *Larix europaea*, *Abies balsamea*, *Picea canadensis*, *Euonymus obovatus*, *Ribes aureum*, *R. gracilis*, and *Helianthus grosse-serratus*, with no infection.

3. UROMYCES JUNCI Tul. from *Juncus tenuis* Willd. was sown on *Iris versicolor*, with no infection.

4. UROMYCES SPOROBOLI E. & E. from *Sporobolus longifolius* (Torr.) Wood was sown on *Ceanothus americanus* and *Verbena stricta*, with no infection.

5. UROMYCES HALSTEDII De T. from *Homalocenchrus virginicus* (Willd.) Britt. was sown on *Senecio obovatus* and *Bidens frondosa*, with no infection.

6. PUCCINIA ELEOCHARIDIS Arth. from *Eleocharis palustris* (L.) R. & S. was sown on *Iris versicolor*, with no infection.

7. PUCCINIA SCHEDONNARDI K. & S. from *Schedonnardus paniculatus* (Nutt.) Trel. was sown on *Lepidium apetalum*, *Ceanothus americanus*, *Oxalis cymosa*, *Apocynum cannabinum*, *Cassia Chamaecrista*, *Symphoricarpos racemosus*, *Xanthium canadense*, *Kuhnistera purpurea*, and *Lacinaria scariosa*, with no infection.

8. PUCCINIA MUHLENBERGIAE A. & H. from *Muhlenbergia racemosa* (Mx.) B. S. P. was sown on *Napaea dioica*, *Impatiens aurea*, *Oxalis cymosa*, *Anemone canadensis* and *A. virginiana*, *Hydrophyllum appendiculatum*, *Phlox divaricata*, *Physalodes Physalodes*, *Apocynum cannabinum*, and *Helianthus grosse-serratus*, with no infection.

9. PUCCINIA CHLORIDIS Speg. from *Chloris verticillata* Nutt. was sown on *Quamasia hyacinthina*, with no infection.

10. PUCCINIA SPOROBOLI Arth. from *Sporobolus heterolepis* Gray was sown on *Isopyrum biternatum*, *Oxalis cymosa*, *Xanthoxylum americanum*, *Ribes Cynosbati*, *Cassia Chamaecrista*, *Symphoricarpos racemosus*, *Verbena urticifolia*, *Senecio obovatus*, *Solidago rigida*, *Helianthus Maximiliani*, *Boltonia asteroides*, and *Brauneria purpurea*, with no infection.

11. PUCCINIA PURPUREA Cke. from *Tripsacum dactyloides* L. was sown on *Zea Mays*, with no infection.

12. PUCCINIA STIPAE Arth. from *Stipa spartea* Trin. was sown on *Aesculus glabra*, *Cassia Chamaecrista*, *Psoralea Onobrychis*, *Symphoricarpos racemosus*, *Hydrophyllum appendiculatum*, *Xanthium canadense*, *Boltonia asteroides*, *Lacinaria scariosa*, and *Brauneria purpurea*, with no infection.

13. PUCCINIA PANICULARIAE Arth. from *Panicularia americana* (Torr.) MacM. was sown on *Boltonia asteroides*, with no infection, although three sowings were made at different dates and with all conditions apparently favorable. This seems to contradict the inference of the writer drawn from field observations (Bull. Torr. Bot. Club **28**: 664).

14. PUCCINIA EMACULATA Schw. from *Panicum capillare* L. was sown on *Impatiens aurea*, *Lactuca canadensis*, and *Eupatorium perfoliatum*, with no infection.

15. PUCCINIA POLYGONI-AMPHIBII Pers. from *Polygonum emersum* (Mx.) Britt. was sown on *Polygonum pennsylvanicum* and *P. virginianum*, with no infection.

Twelve species of rusts were successfully grown, that have been studied with success before, and reported upon by the writer and others. They are enumerated here by way of confirmation, and also in some cases because additional hosts are included. The list is as follows:

1. UROMYCES EUPHORBIAE C. and P.—June 19, aecidiospores from *Euphorbia humistrata* Engelm. were sown on the same host, and were followed by uredo on July 8, and also on *E. nutans* and *E. marginata*, with no infection. July 11, aecidiospores from

E. nutans Lag. were sown on the same host, and were followed by uredo on July 21, and also on *E. humistrata* and *E. marginata*, with no infection. July 22, uredospores from *E. dentata* Michx. were sown on the same host, and were followed by uredo on Aug. 14, and also on *E. humistrata*, *E. nutans*, and *E. marginata*, with no infection. These results, taken in connection with those previously obtained by the writer,[4] leave no opportunity for doubt that the Euphorbia rust is separable into a number of well established races, or possibly into true species.

2. UREDO RUBIGO-VERA DC.—May 31, uredospores from *Triticum vulgare* Vill. were sown on *Triticum vulgare*, and produced uredo on June 13, and at the same time on *Hordeum jubatum*, *Poa compressa*, *Dactylis glomerata*, and *Bromus ciliatus*, with no infection.

3. PUCCINIA PECKII (De T.) Kellerm.—The connection of a Puccinia on *Carex trichocarpa* Muhl. and *Aecidium Peckii* De T. on *Onagra biennis* (L.) Scop. (*Oenothera biennis* L.) has already been reported by Kellerman,[5] and it was due to the suggestion from Professor Kellerman, founded upon his field observations, that the writer succeeded in bringing the present season's work to a satisfactory issue.[6] Eleven collections of teleutospores were used: two from Ohio, sent by Professor Kellerman; two from Racine, Wisconsin, sent by Dr. J. J. Davis; two from Spirit Lake, Iowa, obtained by the writer; and the remainder from different localities near Lafayette, Indiana. Seven of these collections were definitely known to be on *Carex trichocarpa*, and four of them, those from Wisconsin and Iowa, were presumably on that host.

Spores from these collections were sown on *Urtica gracilis*, *Anemone canadensis*, *Geranium maculatum*, *Impatiens aurea*, *Sambucus canadensis*, *Ribes gracile*, *R. Cynosbati* and *R. floridum*, *Xanthium canadense*, *Aster Shortii* and *A. paniculatus*, *Solidago canadensis*, *Erigeron annuus*, and *Leptilon canadensis*, with no infection. Successful cultures on *Onagra biennis* were made as follows, the period between the sowing of the dry spores and the appearance of the spermogonia varying from five to seven days, and between the appearance of the spermogonia and the appearance of the aecidia an equal length of time, the two intervals making ten to thirteen days.

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[4] BOT. GAZ. 29:271. 1900, and Jour. Mycology 8:51. 1902.

[5] Jour. Mycology 8:20. 1902.

[6] For record of previous failures see Jour. Mycology 8:52. 1902.

CULTURES OF PUCCINIA FROM CAREX TRICHOCARPA ON ONAGRA BIENNIS.

Teleutospores sown	Spermogonia appeared	Æcidia appeared
April 26	May 1	May 7
May 2	May 8	May 13
May 2	May 8	May 15
May 2	May 9	May 15
May 5	May 10	May 16
May 7	May 12	May 19
May 7	May 13	May 19
May 7	May 14	May 19
May 7	May 14	May 19
May 9	May 15	May 21
May 27	June 2	June 7
May 28	June 2	June 7
May 29	June 4	June 9

A collection on *Carex stipata* Muhl. also was made near Lafayette, Indiana, spores from which were sown on *Ribes Cynosbati*, *R. floridum*, *R. Uva-crispa*, *Aster paniculatus*, *A. prenanthoides*, *Solidago canadensis*, and *S. serotina*, with no infection. It was not until aecidia were found in the field on seedlings of *Onagra biennis*, growing close to the Carex still bearing dead leaves covered with teleutospores, that the right plant was selected for cultures. Teleutospores were sown on *Onagra biennis* June 23; spermogonia appeared in great abundance July 1, and aecidia July 8.

4. PUCCINIA BOLLEYANA Sacc. and P. ATKINSONIANA Diet.—The connection of *Puccinia Bolleyana*, which occurs on *Carex trichocarpa* Muhl., with *Aecidium Sambuci* Schw. has already been reported by the writer.[7] This has been confirmed by further successful trials. Material gathered from the type locality of *P. Bolleyana*, when examined under the microscope, was found to show only a small proportion of the characteristic spores of

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[7] Jour. Myc. **8**: 55.

this species, and a large proportion of much smaller spores, which were surmised to belong to *Puccinia Peckii*. Sowings were made, May 5, on *Sambucus canadensis* and *Onagra biennis*. May 10, abundant spermogonia appeared on Onagra, followed May 16 by aecidia. On Sambucus spermogonia appeared sparingly May 13, followed by aecidia May 21. The sedge, therefore, bore two species of rust in 1901, intermixed on the same leaves. In addition to this, on May 19, aecidiospores from *Sambucus canadensis* were sown on *Carex trichocarpa*, which gave rise to uredo on May 27. The connection of *Puccinia Bolleyana* with *Aecidium Sambuci* appears to be proven beyond question.

Two collections of *Puccinia Atkinsoniana* on *Carex lurida* Wahl. were sent from Columbus, Ohio, by Professor Kellerman, with the suggestion, which seemed to me at the time very improbable, that the aecidia doubtless occurred on *Sambucus canadensis*. Another collection was secured from the vicinity of Lafayette, Indiana. Two sowings were made on *Onagra biennis* without infection. One sowing from each of the three collections was made on *Sambucus canadensis* with abundant success in each case. The dates are respectively April 28, May 7 and 16; April 29, May 5 and 16; and May 7, 12, and 21. Professor Kellerman has written me that his cultures also gave similar results.

These discoveries led to a careful microscopic study of the two Carex rusts, and there appears to be no reason to question that *P. Atkinsoniana* and *P. Bolleyana* are identical. In the designation of the species it seems necessary on grounds of priority to abandon both these names, however, and it becomes **Puccinia Sambuci** (Schw.), nom. nov.

5. PUCCINIA CARICIS-ASTERIS Arth.— A collection of this species on *Carex foenea* Willd. was sown on *Solidago serotina*, with no infection. It was also sown, May 2, on *Aster paniculatus* Lam., and was followed by spermogonia May 8, and aecidia May 19, thus confirming the writer's previous work.[8]

6. PUCCINIA CARICIS-ERIGERONTIS Arth.— A collection of this rust on *Carex festucacea* Willd. was used for cultures on *Erigeron*

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[8] Jour. Mycology **8**: 54. 1902.

annuus (L.) Pers., *E. philadelphicus* L., and *Leptilon canadense* (L.) Britt., with the most unqualified success. The work of last year[9] is thus confirmed, and additional hosts ascertained.

7. PUCCINIA CARICIS (Schum.) Reb.—A collection of this rust on *Carex stricta* Lam., sent by Rev. J. M. Bates from Callaway, Nebraska, gave rise to aecidia when sown on *Urtica gracilis* Ait., the dates for sowing, appearance of spermogonia and aecidia being respectively May 24, June 2 and 7. The experimental proof of this connection has been reported[10] twice previously for American material. A collection sent by Mr. E. W. D. Holway from Decorah, Iowa, on *Carex riparia* Curt. was sown on *Ribes Cynosbati*, *R. gracile*, *R. aureum*, *R. floridum*, and *R. Uva-crispa*, *Geranium maculatum*, *Onagra biennis*, *Sambucus canadensis*, and *Xanthium canadense*, with no infection. It was sown on *Urtica gracilis* May 21, and gave spermogonia May 27, and aecidia June 2.

8. PUCCINIA VILFAE A. & H.—The alternate form of this rust has been shown[11] to be *Aecidium verbenicola* K. & S. These results have been verified this season by sowing teleutospores from *Sporobolus longifolius* (Torr.) Wood, collected at Callaway, Nebraska, by Rev. J. M. Bates, on *Verbena stricta* Vent. (culture dates May 28, June 3 and 10) and on *V. urticifolia* L. (culture dates the same). A collection from Lafayette, Indiana, on the same host, was also sown on *V. urticifolia* with success (culture dates May 2, 10, and 19). To conform to present knowledge the name of the rust should be written **Puccinia verbenicola** (K. & S.), nom. nov.

9. PUCCINIA WINDSORIAE Schw.—A collection of the teleutospores of this species of rust on *Tricuspis seslerioides* Torr. (*Triodia cuprea* Jacq.) was sent from Denton, Texas, by Mr. W. H. Long, Jr., with the statement that *Æcidium Pteleae* B. & C., which has been taken to be the alternate form of the rust,[12] had not been observed in that vicinity. This material was sown on *Ptelea trifoliata* L., May 9, and spermogonia appeared May 15, followed by abundant aecidia May 24.

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[9] Jour. Mycology **8**: 54. 1902.

[10] BOT. GAZ. **29**: 279. 1900, and Jour. Mycology **8**: 52. 1902.

[11] BOT. GAZ. **29**: 274. 1900.

[12] BOT. GAZ. **29**: 273. 1900.

10. PUCCINIA HELIANTHI Schw.—Cultures showing this species to be autoecious have heretofore been made with American material only by Carleton[13], but have been reported from Europe. Teleutospores gathered in this vicinity on *Helianthus grosse-serratus* Mart. were sown on the same species of host with success (culture dates May 8, 17, and 23) and also on *H. Maximiliani* Schrad. (culture dates May 8, 16, and 22), but sowings at two different dates on *H. strumosus* gave no infection. This evidence of races, so far as it goes, does not accord with Carleton's opinion that "there is no distinction of host forms."

11. PHRAGMIDIUM SPECIOSUM Fr.—A successful culture[14] of this species of rust was again tried, using teleutospores from a hardy garden rose, obtained at Spirit Lake, Iowa, and sowing them on *Rosa humilis* Marsh. The culture was made April 24, and vigorous spermogonia appeared May 3, but the leaves gradually withered without the formation of the aecidial stage.

Beside the foregoing negative and confirmatory results, successful cultures were made establishing aecidial and teleutosporic association, heretofore unknown, for seven species of heteroecious grass and sedge rusts.

1. UROMYCES ARISTIDAE E. & E.—The material for the study of this species was received from Mr. W. H. Long, Jr., who suggested that its aecidial form was to be looked for on various species of Plantago. Teleutospores on *Aristida oligantha* Michx. were collected the middle of March, at Denton, Texas. Sowings were made from this material on *Plantago Rugelii* Dec., May 2, from which spermogonia arose May 13, and aecidia May 20. The development was not luxuriant, but very characteristic. A sowing on the same date on *P. lanceolata*, and later sowings on both species gave no infection. It would seem that these two species of Plantago are less suited to the ready development of the species than other members of the genus. The middle of April I received from Mr. Long freshly gathered aecidia on *Plantago virginica* L., and on two undetermined species, which are doubt-

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[13] Science 13:250. 1901.

[14] For previous record see BOT. GAZ. 29:271. 1900.

less *P. Purshii* R. & S. and *P. aristata* Michx. I also have it in my herbarium on *P. virginica* from Illinois (Ellis and Everhart's N. Amer. Fungi, no. 1829), on *P. Purshii* from Nebraska (Fungi Columbiani, no. 1475), and on *P. eriopoda* Torr. from Montana, collected by F. D. Kelsey. The aecidium has passed under the name of *A. Plantaginis* Ces., but the identity with the European form needs verification, although microscopically the two are very similar.

2. PUCCINIA BARTHOLOMAEI Diet.—Again I am indebted to Mr. W. H. Long, Jr., for material and suggestions leading to the discovery of the aecidial connection of this host. Under date of April 8, 1902, he wrote: "I have never found *Puccinia vexans* in the state, although it is reported from Texas; *P. Bartholomaei* I have found, also its aecidial stage, which is *Aecid. Jamesianum* on *Asclepiodora decumbens*. I have never found this milkweed with aecidia on it, that I did not find teleutospores of *P. Bartholomaei* thickly covering the leaves of *Bouteloua curtipendula* around and under the milkweed, and the teleutospores when examined had germinated. Later the young grass in and near the bunches of infected milkweed would first show the rust; and where no teleutospores were found under or near the milkweed no aecidia were seen. This I observed repeatedly in my field work last year."

Mr. Long sent teleutospores on *Atheropogon curtipendulus* Fourn. (*Bouteloua curtipendula* Torr.), which were sown on *Asclepias incarnata* L. on May 2, giving rise to spermogonia May 8, and aecidia May 17. They were later sown with success on the same host (culture dates, May 21, 28, and June 5), and on *Asclepias syriaca* L. (culture dates, May 12, 18, and 26). They were also sown at two different dates on *Apocynum cannabinum*, with no infection.

As the specific name of the aecidium is older than that of the teleutosporic stage, the name of the fungus should become **Puccinia Jamesiana** (Pk.), nom. nov.

3. AECIDIUM IMPATIENTIS Schw.—The aecidium on Impatiens, and there appears to be but one, is very common throughout the eastern United States. It often occurs in a locality in the great-

est abundance, frequently affecting the leaves and stems of nearly every plant in a large area where the host may be growing thickly. Such a group of plants has been under observation for a number of seasons. In a space some twenty feet across, protected by a group of willows, many hundreds of *Impatiens aurea* Muhl. have sprung up from seeds each succeeding spring, and when from six inches to a foot high have become remarkably infested with aecidia. A rather large number of grass and sedge rusts occur in the vicinity of this spot, and the teleutospores of these have been sown in succession on Impatiens, and invariably with no infection. It was not until well into June of the present year that any clue was obtained. A tuft of *Elymus virginicus* L., growing at the edge of this patch of infested Impatiens, was found to possess young sori of some uredo. Searching further, dead leaves of the previous season were obtained bearing inconspicuous sori of what has generally been called *Puccinia rubigo-vera*, the teleutospores of which had already germinated. A collection on the same host was in the laboratory, however, that had been obtained early in the season from a locality some miles distant, which was still in germinating condition. Teleutospores from this were sown on *Impatiens aurea*, June 10, spermogonia following abundantly June 17, and aecidia June 25. Spores from the same collection had been sown previously on *Ambrosia trifida* and *Napaea dioica*, with no infection.

There are other creditable species of Puccinia on Elymus in the Rocky mountain and Pacific states, but this is the most common species and possibly the only one in the eastern states. It should be called **Puccinia Impatientis** (Schw.), nom. nov.

4. PUCCINIA SUBNITENS Diet.—I am indebted to Rev. J. M. Bates, of Callaway, Nebraska, for material to make the cultural study of this species, and for the suggestion which made the study fruitful. He wrote that wherever the grass rust occurred he had observed an aecidium on *Chenopodium leptophyllum* (Moq.) Nutt.

Teleutospores from *Distichlis spicata* (L.) Greene were sown on *Chenopodium album* L. on May 24, and on May 31 spermogonia appeared in the greatest luxuriance, followed by aecidia on June

3. A second sowing was made May 27, with spermogonia June 3, and aecidia June 9, in equal abundance. The crumpling of the leaves by the aecidia, and their bright orange color, made these the most striking cultures of the season. This aecidium is undoubtedly *A. Ellisii* Tr. & Gall., founded on a collection from New Mexico.

5. PUCCINIA AMPHIGENA Diet—In the year 1883 the type collection for this species was made by the writer at Ravenswood, now a part of Chicago. The same season an aecidium was found on *Smilax herbacea* in the immediate vicinity,[15] which appeared to be *A. Smilacis* Schw. Owing to the limited distribution of these two forms, and their association within a seemingly restricted area, their possible genetic connection was thought worth testing. This opinion was strengthened by the fact that the grass rust has been collected a number of times since by the writer in the same locality, but no other aecidium has been found there at all likely to belong to it.

Teleutospores on *Calamovilfa longifolia* (Hook.) Hack., kindly sent by Rev. J. M. Bates from Callaway, Nebraska, were sown May 13 on both *Smilax herbacea* L. and *S. hispida* Muhl., and on May 20 both showed spermogonia, and May 31 aecidia. A second sowing on May 27 was only partially successful, as the leaves prematurely withered.

6. PUCCINIA SIMILLIMA Arth.—At the time of the publication of this species the writer called attention[16] to its probable connection with an aecidium on *Anemone canadensis*, which occurred in great abundance in the immediate vicinity.

Teleutospores on *Phragmites Phragmites* (L.) Karst. (*P. communis* Trin.), obtained by the writer from the type locality at Spirit Lake, Iowa, were sown on *Anemone canadensis* L., May 1, producing spermogonia May 5, and aecidia May 13. They were also sown, partly at the same time and partly later, on *Anemone cylindrica*, *A. virginiana*, *Pulsatilla hirsutissima*, and *Ranunculus septentrionalis*, all seemingly reasonable hosts, but with no infection. The aecidium has passed for *Aecid. Ranunculacearum*, but whether it is distinct or not from the similar aecidia which have been found on the other hosts mentioned cannot now be stated.

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[15] See BURRILL, Parasitic Fungi of Illinois 238.

[16] BOT GAZ. **34**: 18. 1902.

7. AECIDIUM SOLIDAGINIS Schw.—Having found Puccinia teleutospores on *Carex Jamesii* Schw., they were sown on four species of Ribes, with no infection. They were then sown on six species of Aster, with no infection. At about the same time, May 9, they were sown on *Solidago canadensis* L., and followed by spermogonia May 15, and aecidia May 22. On May 24 a sowing was again made on *S. canadensis*, and also on *S. ulmifolia* Muhl., *S. caesia* L., *S. rigida* L., and *S. serotina* Ait., all of which produced spermogonia in ten to twelve days, but only the last developed aecidia. Part of these trials were repeated, and sowings also made on three additional species of Solidago, but without success. These failures appear to have been due chiefly to the feeble condition of the host plants.

A collection of Puccinia on *Carex stipata* Muhl., sent by Mr. E. W. D. Holway from Decorah, Iowa, was used for cultures on four species of Ribes, and on *Erigeron annuus* and *Onagra biennis*, with no infection. Afterward it was tried, May 27, on *Solidago canadensis*, giving spermogonia June 2 and aecidia June 9. On the same date it was sown on *S. serotina*, giving spermogonia June 2 and aecidia June 11.

As the specific name *Solidaginis* is already employed in the genus Puccinia, I propose for this species the name of **Puccinia Caricis-Solidaginis.** A comparison of this species with *P. Caricis-Asteris* and *P. Caricis-Erigerontis* shows many resemblances, and it seems not improbable that the three represent more correctly the biological variations of one species. However, in the many cultures so far made no set of teleutospores has been found that would infect more than one of the three host genera, Aster, Erigeron, and Solidago.

SUMMARY.

The following is a complete list of successful cultures made during the season of 1902. It is divided into the two series: species previously reported by the writer or other investigators, and species now reported for the first time.

A. SPECIES PREVIOUSLY REPORTED.

1. UROMYCES EUPHORBIAE C. & P.—Aecidiospores from *Euphorbia humistrata* Engelm, sown on same host. Aecidiospores from *E. nutans* Lag. sown on same host. Uredospores from *E. dentata* Michx. sown on same host.

2. UREDO RUBIGO-VERA DC.—Uredospores from *Triticum vulgare* Vill. sown on same host.

3. PUCCINIA PECKII (De T.) Kellerm.—Teleutospores from *Carex trichocarpa* Muhl. and *C. stipata* Muhl. sown on *Onagra biennis* (L.) Scop.

4. PUCCINIA SAMBUCI (Schw.) Arth.—Teleutospores from *Carex trichocarpa* Muhl. and *C. lurida* Wahl. sown on *Sambucus canadensis* L., and aecidiospores from *S. canadensis* L. sown on *C. trichocarpa* Muhl.

5. PUCCINIA CARICIS-ASTERIS Arth.—Teleutospores from *Carex foenea* Willd. sown on *Aster paniculatus* Lam.

6. PUCCINIA CARICIS-ERIGERONTIS Arth.—Teleutospores from *Carex festucacea* Willd. sown on *Erigeron annuus* (L.) Pers., *E. philadelphicus* L., and *Leptilon canadense* (L.) Britt.

7. PUCCINIA CARICIS (Schum.) Reb.—Teleutospores from *Carex stricta* Lam. and *C. riparia* Curt. sown on *Urtica gracilis* Ait.

8. PUCCINIA VERBENICOLA (K. & S.) Arth.—Teleutospores from *Sporobolus longifolius* (Torr.) Wood sown on *Verbena stricta* Vent. and *V. urticifolia* L.

9. PUCCINIA WINDSORIAE Schw.—Teleutospores from *Tricuspis seslerioides* (Michx.) Torr. sown on *Ptelea trifoliata* L.

10. PUCCINIA HELIANTHI Schw.—Teleutospores from *Helianthus grosse-serratus* Mart. sown on same host, and on *H. Maximiliani* Schrad.

11. PHRAGMIDIUM SPECIOSUM Fr.—Teleutospores from cultivated rose sown on *Rosa humilis* Marsh.

B. SPECIES REPORTED NOW FOR THE FIRST TIME.

1. UROMYCES ARISTIDAE E. & E.—Teleutospores from *Aristida oligantha* Michx. sown on *Plantago Rugelii* Dec.

2. PUCCINIA JAMESIANA (Pk.) Arth.—Teleutospores from *Atheropogon curtipendulus* (Michx.) Fourn. sown on *Asclepias incarnata* L. and *A. syriaca* L.

3. PUCCINIA IMPATIENTIS (Schw.) Arth.—Teleutospores from *Elymus virginicus* L. sown on *Impatiens aurea* Muhl.

4. PUCCINIA SUBNITENS Diet.—Teleutospores from *Distichlis spicata* (L.) Greene sown on *Chenopodium album* L.

5. PUCCINIA AMPHIGENA Diet.—Teleutospores from *Calamovilfa longifolia* (Hook.) Hack. sown on *Smilax herbacea* L. and *S. hispida* Muhl.

6. PUCCINIA SIMILLIMA Arth.—Teleutospores from *Phragmites Phragmites* (L.) Karst. sown on *Anemone canadensis* L.

7. PUCCINIA CARICIS-SOLIDAGINIS Arth.—Teleutospores from *Carex Jamesii* Schw. and *C. stipata* Muhl. sown on *Solidago canadensis* L. and *S. serotina* Ait., and also from the former Carex host sown on *S. caesia* L., *S. ulmifolia* Muhl. and *S. rigida* L.

It will not be out of place to emphasize again the desirability of making field observations upon the association of aecidial, uredo, and teleutosporic forms within small areas. There is little chance for progress in establishing the connection of spore-forms through cultural work, except by acting upon the hints derived from field notes. Any acute observer is likely to be able to make one or more important deductions of this kind during a season, which may lead to valuable discoveries upon testing by cultures. If collectors would bear the matter in mind, the perplexing tangle of our knowledge of the heteroecious rusts would soon largely yield to experimental study.

I cannot too heartily express my appreciation of the kindness of Professor W. A. Kellerman, Mr. W. H. Long, Jr., Rev. J. M. Bates, Dr. J. J. Davis, and Mr. E. W. D. Holway, for their assistance with material, and especially with suggestions derived from their field observations. Without such help much of the work recorded in this report could not have been undertaken.

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EXPERIMENTAL STUDIES ON INULASE.

ARTHUR L. DEAN.

In 1888 J. Reynolds Green[1] reported the discovery of an inulin-splitting enzyme in the Jerusalem artichoke, *Helianthus tuberosus*. The tubers were planted and allowed to grow until the stems were about six inches above the ground. At that time the tissues of the tubers were found to have become much altered, being spongy in the middle part, although the outer part was still firm and contained inulin. A glycerine extract of these tubers was prepared and dialysed free from sugar. Such an extract was found to have the power to change inulin to a reducing sugar. Experiments were carried out in test-tubes and in dialysing tubes, with the result that Green was able to establish quite conclusively that the germinating artichoke contained an enzyme able to cause the hydrolysis of inulin. To this enzyme he gave the name "inulase." It is evident from Green's description that the extracts obtained by him were not very active. This he accounts for by supposing the enzyme to occur in very small quantities.

Some time before Green's paper appeared, Bourquelot had observed that *Aspergillus niger* grew well in media in which inulin was the only carbohydrate. Later, in 1893, he[2] published several short papers in which he recorded finding inulase in *Aspergillus niger*. The inulase was associated with several other enzymes, but Bourquelot was convinced that the cleavage of inulin was the function of a distinct ferment. In another paper[3] he compared the enzymes of *Penicillium glaucum* and *Aspergillus niger*, and notes the fact that inulase is present in the first-named fungus.

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[1] On the germination of the Jerusalem artichoke (*Helianthus tuberosus*). Annals of Botany **1**: 223. 1888.

[2] Inulase et fermentation alcoholique indirecte de l'inuline. Compt. Rend. **116**: 1143. 1893. Also in Compt. Rend. Soc. Biol. IX. **5**: 481. 1893. Les ferments solubles d l'*Aspergillus niger*. Buil. Soc. Mycol. France **9**: 230. 1893.

[3] Remarques sur les ferments solubles sécrétés par l' Aspergillus et le Penicillium. Compt. Rend. Soc. Biol. IX. **5**: 653. 1893.

He says nothing concerning the inulase of Penicillium beyond the bare fact of its existence.

Chevastelon[4] was able to cause hydrolysis of the "inulin" from the monocotyledons by the agency of the inulase of Aspergillus.

It seemed of interest to investigate more fully the action of the inulase of Aspergillus and Penicillium, and to discover, if possible, whether or not it was identical with the inulase of the artichoke.

CULTURE METHODS.

Pure cultures of *Aspergillus niger* and *Penicillium glaucum* were obtained, and stock cultures kept on the following medium:

MEDIUM A.—Agar-agar, 10^{gm}; NaCl, 2.5^{gm}; peptone (Grübler's), 2.5^{gm}; beef extract, 1^{gm}; inulin (air dry), 5^{gm}; water, 500^{cc}.

The inulin used in making all culture media was prepared from *Dahlia variabilis* by alcoholic precipitation.

The first experiments were carried out upon Penicillium. A culture fluid having the following composition was prepared:

MEDIUM B.—Inulin, 1.5^{gm}; peptone (Grübler's), 0.5^{gm}; NaCl, 0.5^{gm}; beef extract, trace; water to make 150^{cc}.

Test-tubes containing this liquid were sterilized and inoculated with the spores of Penicillium. The fungus grew well in this medium. Each day the culture fluid of one tube was used to test for the presence of sugar (levulose) in solution. During the first three days no sugar reaction was evident, but after that time a reduction could be obtained by boiling the culture fluid with Fehling's solution. The amount of sugar was small at first, but steadily increased, until, after a week's time, the reaction was very marked.

Five days after inoculation the fluid from several cultures was filtered and heated in a water bath with phenyl-hydrazine hydrochloride and sodium acetate. The osazone formed separated while the solution was in the boiling water bath and had the characteristic crystalline form of glucosazone.

In order to establish the fact that the inulin of the medium was the source of the sugar formed, the following culture fluid was prepared which contained no organic compound except inulin:

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[4] Sur l'inuline d'ail, de la jacinthe, d'asphodèle et de la tubereuse. Jour. Pharm. IV. **2**: 1. 1895.

MEDIUM C.—Inulin, 5^{gm}; KNO_3, 0.5^{gm}; $CaCl_2$, 0.25^{gm}; Na_2So_4, 0.25^{gm}; NaH_2PO_4, 0.25^{gm}; $MgSo_4$, 0.2^{gm}; Fe_2Cl_6, trace; water to make 500^{cc}.

About 50^{cc} of this were placed in each of a number of small Erlenmeyer flasks, which, after sterilization, were inoculated with spores of Penicillium. As in the former case, so here, the fungus grew well, and its growth was followed after a few days by the appearance of a reducing sugar in the culture medium. After nine days of growth the culture fluid contained no inulin.

It was found that *Aspergillus niger* grown in the culture fluids described above caused, after a few days of growth, the same appearance of levulose in the solution. After trying a number of media the following was preferred as producing uniformly vigorous growths of the fungi:

MEDIUM D.—Inulin, 15^{gm}; peptone (Grübler's), 7.5^{gm}; KNO_3, 2^{gm} $CaCl_2$, 1^{gm}; Na_2SO_4, 1^{gm}; $MgSO_4$, 1^{gm}; NaH_2PO_4, 1^{gm}; $FeSO_4$, trace water to make 1500^{cc}.

This solution gave about equally good results when 25^{cc} were placed in small (125^{cc}) Erlenmeyer flasks, or when 75^{cc} were placed in larger (500^{cc}) flasks. Since the growth is almost entirely on the surface, a larger percentage of mycelia is obtained from a given quantity of culture medium if the fluid is in a thin layer. The cultures were grown in the dark at a temperature of 25–30° C.

METHOD OF OBTAINING PREPARATIONS OF INULASE.

Cultures of the fungi were grown as described above until about a week old; the mycelia were then filtered from the culture fluid, washed in distilled water, torn apart with needles, and thrown into a mixture of three parts of absolute alcohol and one part of ether. After remaining in the alcohol and ether about five minutes, the material was filtered off on a Büchner funnel and dried. The mass when ground to a powder yielded, in the case of Aspergillus, a black, and in the case of Penicillium, a grayish-green powder.

The above method was suggested by the procedure recommended by Albert[5] as a simple way to obtain the zymase from yeast. It has proved to be a good method for obtaining very active preparations of the invertin of yeast, and was therefore tried as a method for obtaining inulase from Penicillium and Aspergillus.

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[5] Einfacher Versuch zur Veranschaulichung der Zymase. Ber. Deutsch. Chem. Gesell. **33**: 3775. 1900.

The Penicillium powder was examined first and was tested as follows. A few milligrams of the powder were ground with sand and water, and the mixture added to two test tubes containing a solution of inulin together with a little toluol. One of these tubes was boiled and both were placed in the incubator. After ten hours a very slight reducing power was observable in the unboiled solution. After forty-four hours equal quantities of the boiled and unboiled fluids were tested with the same quantity of Fehling's solution. The result was striking, there being a copious red precipitate of cuprous oxide in the test of the unboiled digestion, and a clear blue liquid in the other. Some of the liquid from the unboiled digestion was filtered and an osazone made. It was apparently glucosazone.

Experiments showed that this Penicillium powder would not yield a reducing sugar on auto-digestion, that it was without action upon a starch paste which was rapidly digested by saliva, but that it would invert cane sugar. The action of Penicillium powder on inulin, however, was not due to an ordinary invertin, since the invertin of yeast was found to be without action upon inulin.

The Aspergillus powder possessed a rather stronger inulin-splitting power than the Penicillium powder.

A number of attempts were made to obtain inulase from the culture fluids in which Penicillium and Aspergillus had been grown. The fluid itself, both before and after removal of the sugar by dialysis, failed to show any power to hydrolyse inulin. The precipitate thrown down in the culture fluid by alcohol contained no inulase. Attempts were made to make use of the well-known property of enzymes — of being carried down by precipitates of neutral salts formed in their solutions. Precipitates of barium sulphate, calcium sulphate, or calcium oxalate thrown down in portions of the culture fluid had no power to act on inulin. From these facts it is probable that inulase acts inside the fungal hyphae and is not secreted into the surrounding medium. In this respect it resembles the zymase and endotrypsin of yeast, and like them belongs to the class of endo-enzymes.

INFLUENCE OF THE REACTION ON THE ACTIVITY OF INULASE.

It seemed desirable to ascertain whether the inulase found by Green in *Helianthus tuberosus* has the same properties as the inulase of the fungi; and whether or not the inulase of Aspergillus is identical with that of Penicillium. A thorough investigation of all the properties of these enzyme preparations has not been made. The most distinctive property given by Green is that alkalies are harmful to the inulase of artichoke, and that very dilute acids facilitate its action. To test the influence of the reaction of the solution upon the activity of the inulase of Aspergillus and Penicillium the following experiments were undertaken.

I. An inulin solution was made with 1.7569^{gm} of inulin dissolved in 155^{cc} of water containing a small amount of toluol. Of this solution 75^{cc} were placed in each of two flasks. To flask *A* were added 30^{cc} of a suspension of 1^{gm} of Aspergillus powder in 35^{cc} of water; to *B*, 30^{cc} of distilled water. Thirteen test-tubes were filled as follows:

No. 1. 10^{cc} from flask *A*[6] + 10^{cc} of 0.0002 normal H_2SO_4
No. 2. 10^{cc} from flask *A* + 10^{cc} of 0.002 normal H_2SO_4
No. 3. 10^{cc} from flask *A* + 10^{cc} of 0.02 normal H_2SO_4
No. 4. 10^{cc} from flask *A* + 10^{cc} of 0.1 normal H_2SO_4
No. 5. 10^{cc} from flask *A* + 10^{cc} of distilled water
No. 6. 10^{cc} from flask *A* + 10^{cc} of distilled water and boiled
No. 7. 10^{cc} from flask *A* + 10^{cc} of 0.0002 normal KOH
No. 8. 10^{cc} from flask *A* + 10^{cc} of 0.002 normal KOH
No. 9. 10^{cc} from flask *A* + 10^{cc} of 0.02 normal KOH
No. 10. 10^{cc} from flask *B* + 10^{cc} of 0.0002 normal H_2SO_4
No. 11. 10^{cc} from flask *B* + 10^{cc} of 0.002 normal H_2SO_4
No. 12. 10^{cc} from flask *B* + 10^{cc} of 0.02 normal H_2SO_4
No. 13. 10^{cc} from flask *B* + 10^{cc} of 0.1 normal H_2SO_4

Each tube was corked and allowed to stand at 35–37° C. for forty-five hours, at the expiration of which each was boiled and allowed to cool. All were filtered, the first few cubic centimeters of each filtrate being thrown away, and 10^{cc} analyzed for levulose by the ordinary gravimetric copper method. The acid solutions without inulase served as controls to show how much of the sugar formed was due to the enzyme and how much to the acid.

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[6] Before each 10^{cc} was removed, the flask was thoroughly shaken in order that equal quantities of the suspended powder might be taken each time.

The results are given below:

No.	Inulase.	Reaction.	Mgms. levulose in 10^{cc}.	Mgms. levulose due to enzyme.
1	Added	0.0001 N. H_2SO_4	65.2	65.2
2	Added	0.001 N. H_2SO_4	41.6	33.8
3	Added	0.01 N. H_2SO_4	52.3	0
4	Added	0.05 N. H_2SO_4	50.5	0
5	Added	Neutral	53.1	53.1
6	Added	Neutral, boiled	....	0
7	Added	0.0001 N. KOH	25.3	25.3
8	Added	0.001 N. KOH	20.0	20.0
9	Added	0.01 N. KOH	....	0
10	Not added	0.0001 N. H_2SO_4	....	....
11	Not added	0.001 N. H_2SO_4	7.8	....
12	Not added	0.01 N. H_2SO_4	50.4	....
13	Not added	0.05 N. H_2SO_4	49.5	....

II. The sixteen test tubes used in this experiment were filled in a way similar to that in experiment I. Each tube was corked and kept for twenty-one hours at 35–37° C. At the expiration of that time the fluid containing acid were neutralized with barium carbonate in substance. All were then boiled, filtered, and made up to 50^{cc}, of which 25^{cc} were analysed in each case. Following are the results:

No.	Inulase.	Reaction.	Mgms. levulose.	Mgms. levulose due to enzyme.
1	Added	0.0001 N. H_2SO_4	35.2	35.2
2	Added	0.0002 N. H_2SO_4	28.9	28.9
3	Added	0.001 N. H_2SO_4	23.2	23.2
4	Added	0.01 N. H_2SO_4	38.8	0
5	Added	0.05 N. H_2SO_4	59.0	0
6	Added	Neutral	27.5	27.5
7	Added	Neutral boiled	....	0
8	Added	0.0001 N. KOH	26.9	26.9
9	Added	0.001 N. KOH	7.0	7.0
10	Added	0.01 N. KOH	....	0
11	Added	0.05 N. KOH	....	0
12	Not added	0.0001 N. H_2SO_4	....	....
13	Not added	0.0002 N. H_2SO_4	....	....
14	Not added	0.001 N. H_2SO_4	....	....
15	Not added	0.01 N. H_2SO_4	39.3	....
16	Not added	0.05 N. H_2SO_4	59.2	....

III. Considerable difference is shown between the two tables in regard to the effect of the presence of 0.0001 normal potassium hydroxide in the solution. Therefore the following experiment was tried. To a solution of inulin Aspergillus powder was added and the fluid shaken. Of this suspension 10^{cc} were measured into each of two test tubes; to one 10^{cc} of 0.0002 normal KOH were added, and to the other 10^{cc} of distilled water. Three drops of thymol solution were added to each. After shaking, both were corked and kept in the incubator for fifty-four hours. At the end of that time the solutions were filtered and analyzed for levulose. Solution containing 0.0001 N. KOH gave 32.0^{mgms}; neutral solution gave 36.6^{mgms}.

IV. Experiment IV was tried with the inulase from *Penicillium glaucum*. The solutions were made up and the tubes filled in a way similar to that in experiments I and II. Each tube, after the addition of five drops of thymol solution, was corked and kept at 38–40° C. for seventy-one hours. At the end of that time the solutions containing acid were neutralized with barium carbonate and all were boiled. After cooling they were filtered through dry filters and each residue washed with 10^{cc} of distilled water added in two portions of 5^{cc} each. The filtrate and wash water were united in each case and 25^{cc} of the solution analyzed for levulose. The results are given in the table below.

No.	Inulase.	Reaction.	Mgms. of levulose in 25^{cc}.	Mgms. of levulose due to enzyme.
1	Added	0.0001 N. H_2SO_4	98.5	98.5
2	Added	0.001 N. H_2SO_4	61.5	31.2
3	Added	0.01 N. H_2SO_4	114.5	....
4	Added	Neutral	71.4	71.4
5	Added	Neutral, boiled	....	....
6	Added	0.0001 N. KOH	64.6	64.6
7	Added	0.001 N. KOH	19.1	19.1
8	Added	0.01 N. KOH	....	....
9	Not added	0.0001 N. H_2SO_4	....	....
10	Not added	0.001 N. H_2SO_4	30.3	....
11	Not added	0.01 N. H_2SO_4	116.0	....

V. In order to ascertain whether the enzyme is destroyed, or only inhibited, by the action of acids and alkalies the following experiment was tried. Four test tubes were filled as follows, the inulin solution used containing Aspergillus powder in suspension:

No. 1. 10^{cc} inulin solution + 10^{cc} of 0.02 N. H_2SO_4
No. 2. 10^{cc} inulin solution + 10^{cc} of 0.1 N. H_2SO_4
No. 3. 10^{cc} inulin solution + 10^{cc} of 0.02 N. KOH
No. 4. 10^{cc} inulin solution + 10^{cc} of 0.1 N. KOH

Each tube was corked and placed in the incubator for twenty-four hours, at the expiration of which the solutions were neutralized; each solution was divided into two parts, one of which was boiled. The resulting eight solutions were kept in the incubator for ten days and then examined for levulose. In no case was more sugar present in the unboiled than in the boiled solution. We may conclude, therefore, that the enzyme had been destroyed in each test.

From an examination of the results of the experiments detailed above, it is evident that the optimum reaction for the inulase of *Aspergillus niger* and of *Penicillium glaucum* is very close to 0.0001 normal acid (sulphuric). This corresponds well with Green's statement concerning the inulase from Helianthus, which, he says, "works most advantageously in a neutral or very faintly acid medium, the best proportion of acid being about 0.001 per cent. of hydrochloric acid." Green also says that "alkalies are deleterious," a fact which agrees with the results of the experiments on inulase from Aspergillus and Penicillium. The reaction of the fluid seems to have the same effect on the enzyme obtained from each of the two fungi.

INFLUENCE OF THE TEMPERATURE ON THE ACTIVITY OF INULASE.

In his recent book on the enzymes Effront[7] states that "the optimum temperature of inulase is found between 50 and 60°." He gives no authority for the statement, neither does he bring forward any experimental evidence. Bourquelot says that inulase survives a temperature of 64°, but makes no statement in regard to its optimum working temperature. Green states that inulase acts better at 40° than at room temperature, but loses its activity at between 70 and 80°. The unusually high temperature given by Effront seemed worthy of investigation, and accordingly the following experiments were undertaken to ascertain the optimum temperature for the inulase of *Aspergillus niger*.

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[7] Enzymes and their application. Translated by Samuel C. Prescott. pp. 249–251. New York. 1902.

I. About 1^{gm} of a very active preparation of Aspergillus powder was extracted for 24 hours in 50^{cc} of water containing a little thymol. The extract was then filtered and added to a solution of about 1^{gm} of inulin and the mixture made up to 150^{cc}. Of this solution 20^{cc} were added to each of seven test-tubes and two drops of toluol added to each tube. All the tubes were corked and kept at the temperatures given below for five hours, at the expiration of which period all were boiled and 15^{cc} from each tube analyzed for levulose with the results given below:

Temperature.	Mgms. of levulose.
10°	37.2
20°	45.4
30°	59.6
40°	78.5
50°	93.1
60°	108.7
70°	38.1

II. One gram of Aspergillus powder was extracted for twenty-four hours in 50^{cc} of water containing a little toluol. The extract was then filtered and added to a solution of 1.7^{gm} inulin in 100^{cc} of water and the mixture then made up to 200^{cc}. Of this solution, 20^{cc} were added to each of eight test-tubes and three drops of toluol added to each tube. Number 8 was then boiled. They were all corked and kept for seven hours at the temperatures given below, at the expiration of which period all were boiled and 15^{cc} from each tube analyzed for levulose with the results given below:

No.	Temperature	Mgms. of levulose
1	20°	13.2
2	30°	18.8
3	40°	21.1
4	50°	29.6
5	60°	26.4
6	65°	11.3
7	70	10.2
8	50° boiled	8.8

III. One gram of Aspergillus powder was extracted for twenty-four hours in 50^{cc} of water containing a little toluol. The extract was filtered and added to a solution of 1.1^{gms} of inulin in 40^{cc} of water and the resulting mixture made up to 100^{cc}. Of this solution 20^{cc} were added to each of five test tubes and three drops of toluol added to each tube. Number 5 was then boiled. All were corked and kept at the temperatures given below for six hours, at the expiration of which all were boiled and 15^{cc} from each tube analysed for levulose with the results given below.

No.	Temperature	Mgms. of levulose
1	40	42.2
2	50	55.5
3	60	51.8
4	65°	19.9
5	50° boiled	20.9

In the first series of tests the optimum temperature was nearer 60° than 50°, but in the second and third series it was nearer 50°. It is noticeable that in the first series of tests the enzyme was evidently present in much larger quantity than in any of the subsequent digestions. In order to discern whether or not the difference in the effect of the temperature was due to a difference in the concentration of the enzyme the following trial was made:

IV. In flask *A* one gram of Aspergillus powder was extracted in 50^{cc} of water plus toluol. In flask *B* 2.5^{gms} of Aspergillus powder were extracted in the same quantity of water. Both extracts were filtered and added to 75^{cc} of the same inulin solution; toluol was added to each, and each solution made up to 150^{cc}. Two series of six test-tubes each were filled from the two solutions, 25^{cc} being placed in each tube. The tests were kept at the temperatures given below for six hours, then boiled, and 20^{cc} from each was analyzed for levulose.

From the results detailed below it appears that the optimum temperature for inulase lies very near to 55°. There is an indication that in more concentrated solutions the optimum temperature is slightly higher. It is a well-known fact that the presence

SERIES A.—Extract from 1^{gm} Aspergillus powder.

Temperature	Mgms. of levulose
40°	22.5
50°	27.1
55°	29.3
60°	25.7
65°	14.7
55° boiled	11.7

SERIES B.—Extract from 2.5^{gms} Aspergillus powder.

Temperature	Mgms. of levulose
40°	59.4
50°	70.6
55°	74.2
60°	71.9
65°	44.9
55° boiled	33.2

of foreign substances—inorganic salts, proteids, etc.—in the solution in which an enzyme is acting will tend to raise the temperature at which destruction of the enzyme takes place, and in many cases to raise its optimum working temperature.[8] It will be of interest to discover whether or not inulase prepared by a more careful method, by which the bulk of all impurities is eliminated, will show a much lower optimum temperature and range itself with those enzymes which act best at about 40° C.

SUMMARY.

1. In confirmation of the results of Bourquelot, inulase was found in the fungi *Aspergillus niger* and *Penicillium glaucum*.

2. The inulase of these fungi does not pass into the culture medium; it is therefore an endo-enzyme.

3. The preparations of inulase from Aspergillus and Penicillium show similar variations in activity due to changes in the reaction of the medium. The enzyme acts most vigorously in a medium containing 0.0001 normal acid (H_2SO_4); greater

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[8] Cf. CHITTENDEN: On digestive proteolysis. pp. 18, 19. New Haven. 1895.—PUGLIESE: Ueber den Einfluss der Erwärmung auf diastatische Fermente. Archiv Gesamm. Physiol. **69**: 115. 1898.

strengths of acids are unfavorable, the enzyme being destroyed by 0.01 normal sulphuric acid. Alkalies hinder the activity of inulase, even 0.0001 normal potassium hydroxide being injurious; 0.01 normal potassium hydroxide destroys the enzyme.

4. The optimum temperature for inulase was found to be about 55° C.

In conclusion, I wish to express my great indebtedness to Professor Lafayette B. Mendel for his able assistance in all parts of this work.

SHEFFIELD LABORATORY OF PHYSIOLOGICAL CHEMISTRY,
YALE UNIVERSITY.

THE DISTRIBUTION OF THE UPLAND PLANT SOCIETIES OF KENT COUNTY, MICHIGAN.[1]

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XLIII.

BURTON EDWARD LIVINGSTON.

(WITH MAP)

INTRODUCTION.

1. CLIMATOLOGY OF THE COUNTY.—Kent county is so situated that it is traversed both by the southern boundary of the pine-forest region and the eastern boundary of the so-called Michigan peach belt. It is also crossed by the Grand River valley, the line of one of the great main channels by which the melting ice of the glacial period reached the Mississippi system and the Gulf, and also the line marking the farthest northern extension within the peninsula of many typically southern plants. The county embraces a rectangular tract of land 38.6^{km} by 57.9^{km} in extent. Its western boundary is a meridian averaging about 37^{km} east of Lake Michigan at its widest part. Lacustrian influence upon the climate is probably felt throughout the county. Owing to the comparatively small extent of area, differences in climate between its different parts could hardly be pronounced enough to cause any marked difference in its vegetation. Also on account of the great distance apart of the stations for meteorological observations, if there were less differences between the climates of different portions of the county, such would not be brought out by any records which have been made. Therefore, a study of these meteorological data can hardly give any clue to the principles underlying plant distribution within the area.[2]

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[1] A less technical account of the survey here presented was published in the Annual Report of the State Board of Geological Survey of Michigan, 1901, pp. 81–103, and it is through the courtesy of Dr. A. C. Lane, state geologist, under whose auspices the work was done, that the present account is published.

[2] Tables of the average temperature and precipitation by months for this region, compiled from the reports of the Michigan section of the U. S. climate and crop service, are to be found in the author's former publication, *loc. cit.*

The range of altitude over the whole county is less than 122^{m}, so that absolute altitude itself, with its concomitant variations in climatic conditions, is not a factor in the distribution of the flora. Differences in *relative* level, however, produce marked variations in the drainage, and hence in the water content of the soils.

2. GEOLOGY OF THE COUNTY.[3]— The bed rock of the area is almost entirely covered to a great depth by glacial drift, only a few small outcrops being found within its limits. The drift is so deep throughout the county that the underlying rock layers have apparently no influence upon the vegetation. But the drift itself presents some very interesting features.[4] The land consists, in general, of two great blocks of till upland lying on either side of a much lower gravel and sand plain of varying width, which extends in an irregular line from about the middle of the northern boundary southward through Cedar Springs, Rockford, Plainfield, Grand Rapids, Fisher, Carlisle, and Ross, and cutting the southern boundary about 4.8^{km} east of the southwest angle of the county. This plain traces the path of the outflowing water as the Michigan ice sheet retreated northward at the end of the last glacial epoch. An indentation or embayment in the southern ice margin during this retreat marked the junction of the two lobes of the glacier, the eastern lobe coming from the region of Saginaw Bay, the western from that of Lake Michigan. It was naturally into this embayment that much of the water was discharged during the melting process, and the line of sandy plains just traced marks, from Carlisle northward, the path of this gradually increasing notch in the edge of the ice. Southward of Carlisle the Green Lake sand and gravel plain (in Allegan and Barry counties) originated in the same way.

Three well-marked terminal moraines lie partly within the area. The southernmost, and hence earliest formed of these, follows roughly a line drawn through Ross, Carlisle, Middleville, and Hastings. The second passes through the middle of the county, the southern edge being now the northern boundary of the Grand River valley. The third moraine has its highest point northeast of Cedar Springs, and extends in an irregular and broken manner southeastward to the vicinity of Harvard, and northward and westward to Kent City and Casnovia. The second moraine is broken through by the valley of the Rouge River, and the third by the same valley and also by the sand plain north of Cedar Springs. These moraines are usually bordered by sand plains on the outwash side and by till plains on the side which was toward the ice sheet.

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[3] For a more detailed account of these features, see the author's previous publication on the same subject, already cited. A brief description of these features, by Dr. A. C. Lane, will be found in the introduction to MISS E. J. COLE'S *Grand Rapids Flora*, Grand Rapids, 1901.

[4] For aid in interpreting the glacial topography I am indebted to Mr. Frank Leverett, of the U. S. Geological Survey.

Most of the surface soil of the county is predominantly sandy. In classifying soils and designating them on the map, no attempt has been made to distinguish the different gradations between clay and sand. All soils which could not be termed either clay or sand have been bunched together as loam, in the broadest sense of that word, and denoted on the map by dots. More accurate records were made, but it was found that these minor differences of soil bore no apparent relation to the nature of the societies recorded, and it was thought best not to encumber the map with unnecessary details. Clay is denoted on the map by horizontal lines, sand by an absence of any marking. Sand and gravel plains of limited extent lie along almost every creek and about many of the lakes. No attempt has been made to map these smaller deposits.

3. METHODS.—Owing to the large proportion of cultivated land in the county, and the correspondingly small proportion which is in an approximately natural state, a study of the natural plant societies is necessarily a difficult one. From the more or less natural areas which still remain, an attempt has been made to reconstruct, as accurately as possible, the plant societies which occupied the region at the time of settlement. The effects of pasturing in wood lots have been allowed for so far as possible. Information has been gathered from local residents as to the nature of the forest which was removed in making certain fields

ready for the plow, and this information has been of great service in some instances.

The vegetation of the area falls naturally into two groups, that growing on what is commonly termed dry ground and that found in moist or swampy places. Each of these groups can be separated into several societies, which often merge gradually into one another, so that in some localities it appears that there is a mixture of several of them. But in general the division is sufficiently well marked. In the present paper attention will be confined to the upland group.[5]

THE PLANT SOCIETIES.

1. **Classification.**—The vegetation of the upland falls into five societies, which may be characterized as follows:

I. *Beech-maple society*, comprising as predominant and characteristic the following plants: beech, sugar maple, enchanter's nightshade (Circaea), wild licorice (*Galium lanceolatum*), wood nettle (Laportea), catnip (Nepeta), pokeweed (Phytolacca), richweed (Pilea), nightshade (*Solanum nigrum*), and red-berried elder.

II. *Maple-elm-agrimony society*, comprising sugar maple, American and rock elms, agrimony, spikenard (*Aralia racemosa*), honewort (Cryptotaenia), spice-bush (Lindera), moonseed (Menispermum), black snake-root (Sanicula), and wild black cherry.

III. *Oak-hickory society*, comprising white and red oak (*Quercus rubra coccinea*), shag-bark and pig-nut hickory, false Solomon's seal (*Smilacina racemosa*), northern bedstraw (*Galium boreale*), *Aster laevis*, and panicled cornel. This society is much the same as the following, but with the addition of the two hickories. It also has many plants in common with the previous society, and may be regarded as an intermediate type between II and IV, both of which are much more distinct. Owing to the difficulty of distinguishing sharply between *Quercus coccinea* and *Q. rubra*, these two forms have been brought together under the name *Q. rubra coccinea*.

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[5] The study of the lowlands was not thorough. The reader will find a general statement of the lowland conditions in the previously published account, *loc. cit.*

IV. *Oak-hazel society*, comprising white and red oaks, *Aster laevis*, *A. macrophyllus*, New Jersey tea, hazel, spurge (Euphorbia), *Helianthus occidentalis*, *Solidago caesia*, and hoary pea (Tephrosia). The spurge found in this society is the broad-leaved form. In the following society this plant is just as common and characteristic as here, but there it has much narrower leaves. The individuals of the broad-leaved form appear stronger, greener, and more robust than the others.

V. *Oak-pine-sassafras society*, comprising white and red oaks, white pine, sassafras, plantain-leaved everlasting (Antennaria), wormwood (Artemisia), sand bur, spurge (narrow-leaved form), huckleberry (Gaylussacia), lupine, sweet fern, bracken, and *Solidago nemoralis*. This includes the dryest and most open form of "oak openings," together with the country which was once quite well covered with pine. They are put together here, because, aside from the now partially extinct white pine, the floras are practically the same.

A more extensive list of plants is given in the following table, which shows almost graphically the distribution of the enumerated plants throughout the five societies. The nomenclature is that of the sixth edition of Gray's *Manual*. The Roman numerals heading the five columns at the right of the names indicate the societies by number, the same method of indication being also adopted on the map. The letters opposite the plant names show in what societies the plant occurs, the relative abundance in that society being denoted by the letter itself. C denotes common: F, frequent; R, rare. An asterisk accompanying the letter expresses the fact that the plant is one of those to be regarded as specially characteristic of that society. Our *rare* has not the meaning given the word by the systematist; plants which he would consider rare are not sufficiently abundant to be considered at all in such a list as the present.

2. **Distribution.**—The distribution of the societies is shown on the map. From the darkest to the lightest of the five shades used a gradation is shown corresponding to that in the societies from I to V. The sixth and lightest shade denotes deeply-eroded channels occupied chiefly by lowland societies. In these

TABLE OF THE UPLAND PLANT SOCIETIES.

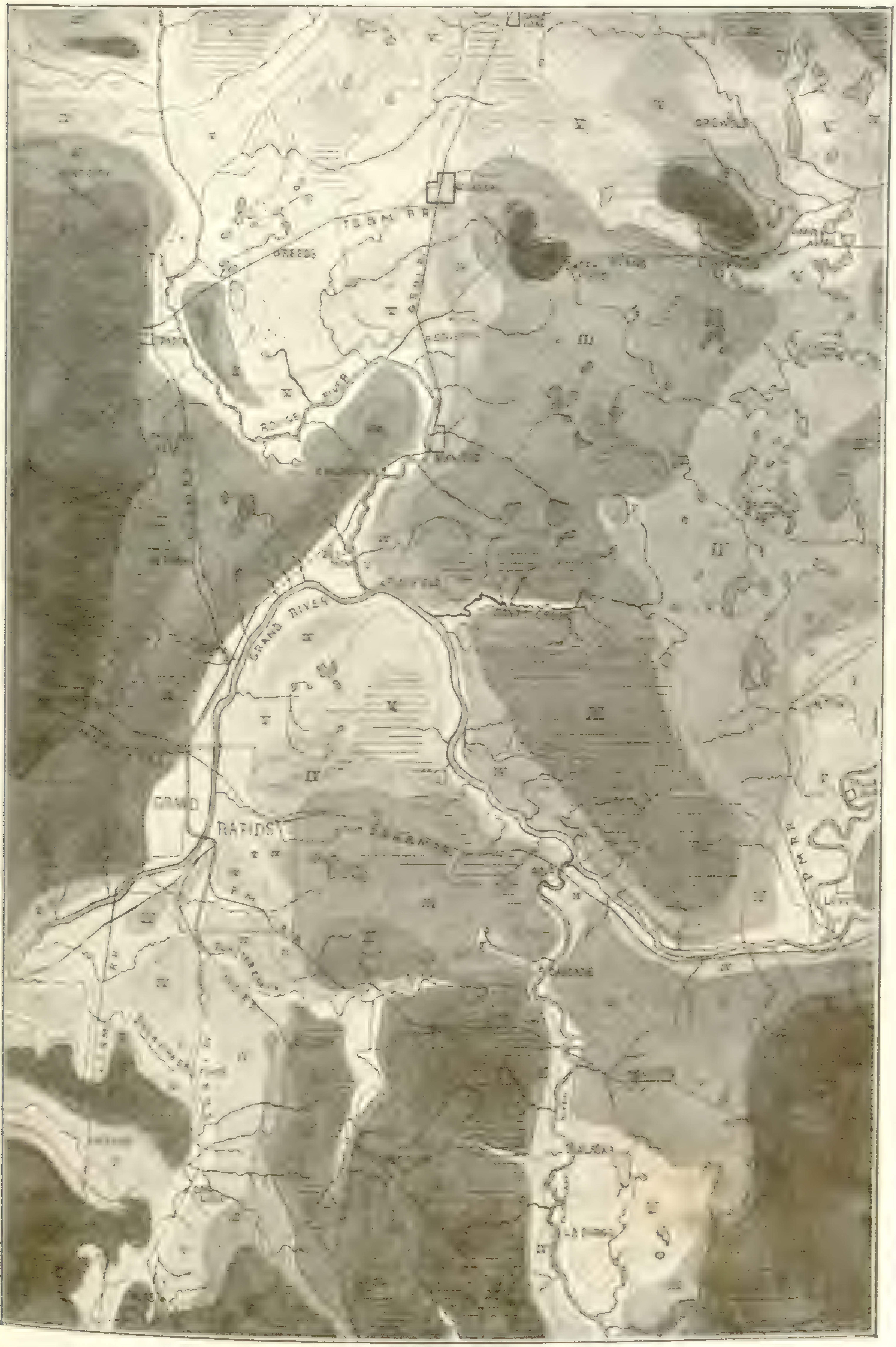
Species	Common name	I	II	III	IV	V
Acalypha virginica	Three-seeded mercury	F	F			
Acer rubrum	Red or swamp maple	R	F	R		
Acer saccharinum	Sugar or rock maple	C*	C	R		
Actaea alba	White baneberry	F*				
Adiantum pedatum	Maidenhair fern		F			
Agrimonia Eupatoria	Agrimony		C*	F		
Andropogon furcatus	Beard grass					C*
Antennaria plantaginifolia	Plantain-leaved everlasting					C*
Aralia racemosa	Spikenard		C*	F		
Artemisia caudata	Wormwood					C*
Aspidium acrostichoides	Christmas fern	F*				
Aster cordifolius		F	C	C		
Aster laevis				C	C*	
Aster macrophyllus				F	C*	
Boehmeria cylindrica	False nettle	C*	F	R		
Carpinus caroliniana	Blue or water beech		C*			
Carya alba	Shag bark hickory		F	C*	R	
Carya porcina	Pig-nut hickory		F	C*	R	
Ceanothus americanus	New Jersey tea			R	C*	F
Cenchrus tribuloides	Sand bur					F*
Chimaphila umbellata	Prince's pine			R	R	F*
Circaea Lutetiana	Enchanter's nightshade	C*	R			
Cornus alternifolia	Alternate leaved cornel		C	C		
Cornus florida	Flowering dogwood		C	F		
Corylus americana	Hazel			F	C*	F
Cryptotaenia canadensis	Honewort		C*	F		
Cynoglossum virginicum	Hound's tongue	F*	R			
Diervilla trifida	Bush honeysuckle				F	C*
Dracocephalum parviflorum	Dragon head	F*				
Echinospermum virginicum	Beggars lice	C*	R			
Epigaea repens	Trailing arbutus					F*
Epiphegus virginiana	Beech drops	C*				
Euphorbia corollata	Spurge			F*	C[6]	C*[7]
Fagus ferruginea	American beech	C*	R			
Galium boreale	Northern bedstraw		F	C*		
Galium circaezans	Wild licorice	F*	R			
Galium lanceolatum	Wild licorice	C*	R			
Gaultheria procumbens	Wintergreen				F	C*
Gaylussacia resinosa	Black huckleberry				F	C*
Gerardia quercifolia	Smooth false foxglove			F	F	F
Geum album	Avens		C*	R		
Hedeoma pulegioides	American pennyroyal	F*				
Helianthus divaricatus	Sunflower		R	F	C	C*
Helianthus occidentalis	Sunflower			F	C*	F
Hepatica acutiloba	Liverleaf	C	C*	C		
Hepatica triloba	Liverleaf			C	C*	
Hieracium scabrum	Hawkweed			F	F	C*
Juglans cinerea	Butternut		F	R		
Juglans nigra	Black walnut		F	R		
Laportea canadensis	Wood nettle	C*	F			
Lechea minor	Pinweed					C*

[6] Broad-leaved form.

[7] Narrow-leaved form.

TABLE OF THE UPLAND PLANT SOCIETIES—*continued.*

Species	Common name	I	II	III	IV	V
Lespedeza polystachya	Bush clover				F.	C*
Lespedeza Stuvei intermedia	Bush clover					C*
Liatris cylindracea	Blazing star					C*
Liatris scariosa	Blazing star					C*
Lindera Benzoin	Spice bush		C*			
Lobelia inflata	Indian tobacco	C*	R			
Lupinus perennis	Wild lupine				R	C*
Medeola virginiana	Indian cucumber root	F*				
Melampyrum americanum	Cow wheat				F	F*
Menispermum canadense	Moonseed		C*	F		
Monarda fistulosa	Wild bergamot, horse mint, balm			F	F	C*
Monarda punctata	Horse mint					F*
Myrica asplenifolia	Sweet fern					C*
Nepeta Cataria	Catnip	C*				
Onoclea sensibilis	Sensitive fern		F*			
Ostrya virginica	Ironwood		C	C		
Phlox subulata	Moss pink					F*
Phryma Leptostachya	Lopseed		F*	R		
Physalis virginiana	Ground cherry					C*
Phytolacca decandra	Pokeweed	C*				
Pilea pumila	Richweed	C*				
Pinus Strobus	White pine				F	C*
Polygonatum giganteum	Solomon's seal		C	F		
Populus grandidentata	Large toothed aspen					C*
Prenanthes alba	Rattlesnake root		R	F	C*	
Prunus serotina	Wild black cherry		F*			
Prunus virginiana	Choke cherry			F	C*	
Pteris aquilina	Braken				F	C*
Pyrola elliptica	Shinleaf					F*
Quercus alba	White oak		R	F	C*	C*
Quercus ilicifolia	Black scrub oak					F*
Quercus rubra-coccinea	Red or black oak		R	F	C*	C*
Rhus copallina	Dwarf sumach				R	F*
Ribes Cynosbati	Gooseberry	C*	F			
Rudbeckia hirta	Browneyed Susan			R	R	C*
Sambucus racemosa	Red berried elder	C*	R			
Sanicula marylandica	Black snake-root		C*	F		
Sassafras officinale	Sassafras			R	R	C*
Smilacina racemosa	False Solomon's seal		C	C		
Smilax hispida	Greenbrier		F	R		
Solanum nigrum	Nightshade	C*				
Solidago bicolor concolor	Goldenrod			F	F	C*
Solidago caesia	Goldenrod			F	C	C
Solidago nemoralis	Goldenrod					C*
Solidago rugosa	Goldenrod		C*	F		
Tephrosia virginiana	Hoary pea			R	C*	C
Tilia americana	Basswood	C	C	F		
Ulmus americana	White or American elm	R	C*	F		
Ulmus racemosa	Rock elm	R	C*	F		
Vaccinium canadense	Blueberry			F	C	C
Vaccinium pennsylvanicum	Dwarf blueberry			F	C	C
Vicia caroliniana	Vetch		F	C*	C	
Vitis cordifolia	Frost grape		C	C		


ROGUE RIVER
T.S.&M.R.R.
CREEDS
GRAND RIVER
GRAND
RAPIDS
P.M.R.R.

UPLAND PLANT SOCIETIES
KENT CO., MICHIGAN.

MORAINE MARGIN ||||||||||
TILL PLAIN MARGIN ⌒⌒⌒⌒
CHANNEL MARGIN - - - - -
CLAY AREA ≡
LOAM AREA ∴

channels the areas occupied by the different societies are so limited that any satisfactory representation of them on the scale of the present map was deemed impossible. Therefore they are left unshaded. Also the lowland societies along the margins of smaller streams and lakes and in swamps among the hills are omitted entirely from the map. The reason for this is in part the same as the one given for the larger channels, and also in part this, that although some of the swamps are large enough to map well on the present scale, yet to trace their margins accurately would require more time than it would be worth, and to map them inaccurately would not be true to the instinct of the work.

Steep slopes where erosion is at present rapid, as along the margins of the many stream valleys and along old glacial channels, are occupied by societies III, IV, and V. The character of the soil seems to make no difference here, the drainage being quite complete and the accumulation of humus impossible. It has also been found impracticable to indicate these very narrow areas upon the map.

In the southern tier of townships, all the heavy clay soil, whether it be rolling moraine or level till plain, was originally occupied by the beech-maple society (I). In the lighter loamy soils are usually found the oak-hickory society (III), with transition zones between it and I held by the maple-elm-agrimony society (II). The very sandy loam bordering the deep narrow valley of the Thornapple River, and spreading eastward from Alaska and Labarge nearly to the Elmdale till plain, is occupied by the oak-hazel and the oak-pine-sassafras societies (IV and V). This loam is in many places as sandy as the soil of the Grand River sand plain; it might almost have been denoted as sand.

Within the "big bend" of the Grand River is an area of decidedly clayey country occupied by the oak-pine-sassafras society (V), although here the pine is not at all prominent. It appears as though this area were well on the way toward society IV at the time of clearing. But the marked presence of sassafras, wormwood, sand bur, *Solidago nemoralis*, and other forms of society V, makes it impossible to classify it elsewhere.

The Grand Rapids sand plain (reaching from Rockford, through Plainfield and Grand Rapids to Grandville and Ross) is generally covered with societies IV and V. The foundation soil is apparently the same throughout, being a gravelly sand, but the areas of society IV have undoubtedly more surface humus, thus giving the soil a darker color and a more loamy texture. The higher parts of the plain, and hence the portions which have been out of water longest, are generally the portions which show this condition. The lower portions where violent water action probably continued after the main stream receded, and where, owing to the slope, erosion is even now well marked, bear little surface humus and are characterized by society V. Here, at the time of clearing, the pine was usually present. Transition areas between IV and V were covered with "oak openings," however. Much of these channel areas is swampy and hence thrown out of the present discussion.

North of Grand River it is only in the western column of townships that the heavy clay is characteristically covered with society I. In other portions of the region the clay is mainly covered with society III, IV, or V. It will be noticed that clay which bears the oak-pine-sassafras society is common in the extreme north and becomes less common southward. Societies III and IV approach each other in character as we pass northward. The hickories become less frequent and the general aspect of III becomes more that of IV. It needs to be remarked here also that the stretch of society III, reaching from the Rouge River southward and lying west of Grand Rapids, is a curious mixture of II and IV. Judging from the trees alone, the southern part of it should be placed in society II, but the presence of New Jersey tea, *Solidago caesia*, etc., seems to place it in the oak-hazel group. Sassafras is present here to a remarkable extent, and in many places, especially to the north, white pine also. The northern part of this stretch contains much pine. Altogether, the area can better be classified under III than otherwise. In the general discussion to follow the possible reasons for the mixing will be considered.

In the bit of beech-maple society in the extreme northwestern part of the county is found the only marked instance of the presence of hemlock. This tree belongs typically with the hard wood group in northern Michigan.

In the northern part of the county white pine was almost universally present in the uplands at the time of settlement. This can be proven by stumps which are still in place or have been used in the construction of stump fences. There are pine stumps and a few trees still standing even in the beech-maple group upon areas north of an east and west line drawn through a point about midway between Cedar Springs and Rockford. South of this line the pine disappears in society I and becomes very rare in all but IV and V.

3. **Generalizations on the upland flora.**—Any sort of generalization upon the study of such a limited area as the present must necessarily be a hazardous undertaking. I venture to call attention to the following points, however, all of which must be looked upon as merely tentative suggestions:

a. *The soil factor.*—It appears that the general distribution of the upland societies is based primarily upon the nature of the superficial soil. This must be so, since the roots of the smaller plants never penetrate very far into the soil, and since, in the case of trees and shrubs seed germination and the growth of seedlings is conditioned by the surface layers. If seedlings cannot develop it is clear that there can be no mature plants.

It is very probable that the original till material covering Kent county was reasonably uniform in chemical constituents. That it was thoroughly mixed by the movement of the ice sheet is shown by the wealth of different minerals to be found in any small region. In spite of the marked washing, the most sandy soils contain a considerable amount of minerals other than silica.[8] The plant can make use of the soil constituents only after they are in aqueous solution. The great bulk of the soil is practically insoluble in water, and it makes no difference to the plant what may be the chemical nature of these undissolved substances. Thus it would seem much more to the point to make analyses of the soil water, for it is this which affects the plant directly. Such analyses were not made in connection with the present work, but it is hoped that they will be made at some future time, either for this region or some similar one. It is very probable, however, that soil waters from the surface soil in different parts of this area will be found to be very nearly uniform in the salts contained. This conclusion results from two considerations: first, the chemical nature of the soluble part of the surface soil itself is very nearly uniform throughout the county; second, the washed soils are usually comparatively shallow, and upward diffusion of dissolved substances probably takes place with comparative rapidity, especially when aided by the soil currents produced by changes of temperature, evaporation, etc. The only localities where it is at all probable that a paucity in soluble salts will be found to occur in the soil water are the deep sand plains. There is some rather questionable evidence from the vegetation that such is the case in these localities, but as yet no definite decision can be made in this regard.

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[8] KEDZIE, R. C., Analysis of soil of jack-pine plains near Grayling, Michigan. Annual Report Mich. Board of Agriculture **27**: 211. 1888; also Bull. 99, 1893.

In classifying soils according to their physical nature, the only question which has any direct bearing upon plant growth is that of the ability of the soil to retain water by capillarity, so-called. Primarily, this ability depends upon the size of the soil particles. Thus sand will retain less water than will loam, and loam will retain less than clay. Sandy soil may be made to retain more water in two different ways, either by the addition of clay or by the addition of humus. The physical effect of humus is very well marked. Of course the humus also adds some nitric acid and certain organic materials which are of benefit to the plant, and it also increases the amount of soluble salts at or near the surface; for humus is formed mainly from leaves, and in these organs the mineral part of the plant body is concentrated. This is perhaps an important fact in the growth of hard wood upon deep sand which is well covered with humus. Where drainage is complete and rapid, as in sand, and oxidation is also rapid, humus does not readily accumulate; but where it does accumulate as a surface layer, the ability of the soil to retain water approaches that of clay.

From the present study it appears that the most important soil factor in the distribution of the flora of Kent county is this one of the relative ability of the superficial layers to retain water. In other words, *the controlling soil condition is one of drainage.*

Throughout the southern half of the county, soils which retain much water are covered with society I, II, or III. The only exception to this is the small clay area within the bend of Grand River. The soil of this area is apparently as good as that farther south, but it is very dry in dry weather, and there is no marked humus covering. Perhaps the proximity to the well drained valley on either hand has an influence through underground drainage, but this was not looked into, and the question must be left for the present unanswered.

Within the sand plain area of the southern half of the county there are several small stretches of societies I and II. Owing to the fact that at one time a much larger stream than the present one flowed through the valley of the Thornapple River, that valley has a well marked terrace between the country level and the present flood plain. This old flood plain is sandy and corresponds in manner of formation to the Grand Rapids sand plain. But in very many places this terrace is covered with societies I or II. Some of the finest "sugar bushes" to be seen in the county are here. The sandy soil is thickly covered with a layer of humus. These strips of hardwood are so narrow that they could not well be shown upon the map. The same condition holds on the rather high part of the plain lying west of Crosby. This is indicated upon the map. Also at the base of the escarpment forming the margin of the deeper glacial channel in the Grand Rapids sand plain, there are several instances of societies I and II upon humus-covered sand. Notably is this true near the southwest corner of Grand Rapids and on the margin of the Buck Creek valley near the Lake Shore and Michigan Southern railroad. In this connection it is interesting to note that beech trees are found quite commonly upon the humus-covered established dunes along the east shore of Lake Michigan.[9]

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[9] Dr. Cowles tells me that he has seen these beech covered dunes as far north as Frankfort, and Mr. Whitford has observed them on Manitou Island.

In the northern half of the county, west of the Rouge River, we find the heavier soils still retaining societies I, II, and III. East of the valley of this river we find the country is much cut up. The clay areas are small and rather well drained. They may be occupied by any society from I to V. That they can support society I is well shown by its occurrence in several places. Its general absence from this region is perhaps due to another cause, to be mentioned later.

East of Sparta and northeast of Cedar Springs are perfectly typical examples of society I growing upon light soil, the former without trace of pine. In the western part of the Sheffield area I was told by a resident that the clay was at least twenty feet below the surface. But in these areas the soil is deeply covered with humus. What the conditions are which cause the accumulation of humus in one place and not in another apparently similar place, I was unable to make out. This accumulation most often occurs in rather low regions, where the sand would normally remain moist longer than elsewhere. The maple-elm-agrimony society grows to perfection on heavy soil with little or no true humus. It is also found on lighter soil which has a humus covering.

In the southern half of the county it seems fairly clear, then, that societies I and II will grow on rather deep sand if that be covered wiih humus, and that when society V is found on clay it is well drained and usually with little or no humus. Throughout the county there is an obvious difference in humus content between the areas occupied by societies IV and V, the sand of the former being mixed with vegetable débris The intermediate society III is found on the loamy soils and on the dryer and better drained clay areas.

b. *The historic factor.*—Besides the factor of relative water content in the soils there is another which may be active in this region, namely, what may be termed the historic factor. As the ice sheet retreated slowly northward at the end of the last glacial period, the portions of Kent county first uncovered were of course in the southern part. And the first parts of the sand plains to be uncovered lay also at the south, although these areas

Mo. Bot. Garden
1904.

were probably under water long after the ice itself had disappeared. It is probable that the pine-heath[10] group, which today reaches farthest north, reached well toward the glacier front during the ice age. And at the end of that age, the ice in its retreat was probably followed northward by vegetation, the pine-heath society leading the way. Near the ice margin the soils were probably raw, absolutely without humus, subject to great drought in summer and to extreme cold in winter. These are just the conditions in which the pine-heath group is found today in northern Michigan. It is probable that at one time they occupied all of Kent county, but the climate became warmer and more equable with the farther retreat of the ice, and the growth of the hardy pines, etc., produced a little humus. Their roots fixed the soil so that erosion was less rapid and perhaps the sassafras and the white and red oaks and the whole of our society V gradually crept in, occupying the better part of the ground along with the pines and heaths. Then, as the soil improved, the oaks became more and more numerous, and the pine seedlings could not develop on account of the shade. The pines thus became fewer in the south and the oaks at last predominant. This would be the stage of society IV. But the process of working over the soil continued, though perhaps the ice-sheet had shrunken by this time nearly to its present size, and humus continued to accumulate in favored places; the hickories, maples, and beeches of Ohio and Indiana spread continually northward over every suitable stretch of soil, as fast as it was made fit for them. When the maples and beeches reached maturity in the richest parts of the oak and hickory forest, the oaks and hickories probably ceased to mature. Seedlings of these trees fail to develop well under maples and beeches, possibly on account of the dense shade. Thus the stage of society I might be reached.

In such a northward advance, the plant societies would not progress in uniform lines. On the contrary, there would be many mixed areas, and the advance would often be almost imperceptible. Here and there in a sterile, perhaps in a well drained, portion, would be left a detachment of the advance guard, like the patches of societies V and IV in the southern townships of the county. And these would be surrounded and left as relics by the later comers as they advanced, occupying all soils in which they could come to maturity, and preventing the development of new generations of the forms previously in possession. With these thoughts in mind, a glance at the map will suggest much more than was suggested before.

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[10] This group comprises, besides several pines, two species of juniper, bearberry, hairbell, bracken, and several of the other forms found in our society V. Cf. WHITFORD, H. N. The genetic development of the forests of northern Michigan; a study in physiographic ecology. BOT. GAZ. **31**: 289–325. 1901.

The beech and maple societies (considered by Cowles and Whitford[11] to be the climax society for temperate North America) extend northward along the lines of soil richest in water content, and reach farthest north in the western part of the county. This latter fact may be due to the lake influence. Chamberlin states[12] that in Wisconsin the beech is limited to regions near the lake. He believes its distribution to be determined by lacustrian climate. This is very doubtful, however. Also the other societies—II, III, and IV—are each a little in advance of the previous one, and each is apparently advancing into the area occupied by the next hardier one. In the extreme north we find almost the entire area occupied by societies IV and V.

According to this line of thought, the reason for the predominance of the pine groups in the northern part of the county is that sufficient time has not yet elapsed since the glacial period for these areas to be reached by the societies found predominant farther south. Along a wavy east and west line passing through Rockford lies the "zone of tension" between societies I, II, and III on the one hand, and IV and V on the other. This line bends far northward at the west, following the western edge of the Rouge valley as far as Kent City and Casnovia. It also bends northward to Sheffield and Harvard on the other side of the Rouge valley. It may be that the climate, somewhat colder as we pass northward, has acted as a retarding factor, assisted by the fact that a good portion of these northern townships have a light surface soil, which seems unsuited for the hard wood societies in the absence of humus. That the climatic factor is not the main one in this is shown by the existence of vast reaches of typical maple and beech forest in the northern part of the peninsula.

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[11] WHITFORD, H. N., *loc. cit.*, p. 302.

[12] CHAMBERLIN, T. C., Native vegetation of Wisconsin. Geol. of E. Wisconsin 2:176. 1873–1877.

The strongest point in favor of the idea just expressed is found in the fact that at the time of settlement practically all of societies I and II in the northern part of the county were well mixed with pine. In some places the pine stumps are so numerous as to raise the question whether the hardwood is not an entirely recent development. It is probable, however, that scattered maples and beeches were mingled with the pine, and that on the removal of the latter their seedlings simply took possession of the ground and shut out the pine seedlings.[13] Also in societies II and III, west of Rockford and as far south as Mill Creek, the pine is still pronounced, and in many small spots society IV, or even V, still retains its hold. As has been noted before, this is a mixed group and is hard to classify. There are no traces of pine in the hard wood forests to the southward. It may well be, however, that a further extension of this study will show that this hypothesis of the historic factor is utterly untenable.

Another line of evidence seeming to throw some light upon the historical development of this flora is that obtained from a comparison of the several sand plains of the region. There is a well marked sand plain just south of the boundary of Kent county, which I have termed the Green Lake sand plain. The soil here is like that of the higher part of the Grand Rapids plain, very sandy, but with a good admixture and coating of humus so that at the surface it appears loamy. The vegetation is made up of all five of our societies. In general the type is that of society III, but there are many spots, especially on the margins of the numerous ponds and lakes where societies IV and V hold the ground. In slight depressions along the margin of the plain the humus is deep and society I is common. There are also many rather large areas of societies I and III well out in the plain. Usually these are in slight depressions, not low enough to be swampy, but well covered with humus. We may say, then, that in the most southern of the three sand plains which have been studied, and therefore the one which has been out of water and fit for vegetation the longest, the predominant society is III; but I and II are not uncommon; while IV and V occupy a relatively small portion of the area.

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[13] Beal has shown that oaks, maples, etc., can reach a considerable age in dense forests without any marked growth. An oak may thus be twenty-five years old and yet have a height of only a few inches. If the shade-producing plants are removed these dwarfed trees will set up a renewed growth. For figures of such dwarfed trees see BEAL, W. J., Observations on the succession of plants in northern Michigan. Annual Report Mich. State Board of Agriculture **27**: 74–78. 1888.

In the Grand Rapids sand plain, society IV is predominant, with a good part occupied by V and comparatively very little by I, II, and III. And in the plain which extends from Rockford northward, the only upland society found is V. Of course the last plain has been out of the water a much shorter time than the other two. In fact, a great part of it is at present swamp and is occupied by lowland societies.

In these three plains, perhaps, are seen successive stages of vegetation occupying successive stages in the formation and accumulation of humus. Of course the extensive destruction of the natural vegetation which has taken place since settlement of this region began will make it impossible for the natural course of events to continue here, even if the above hypothesis be the correct one. Clearing and burning have often reduced the soil from a condition suited to society II or III to one only fit for society V. This is probably also true on the moraines in the northern part of the county. It will probably be impossible ever to trace the history much farther than it had gone at the time of settlement.

CONCLUSIONS.

The present observations appear to justify the retention, as a broad general hypothesis, of the physiographic idea advanced by Cowles, namely, that physiography determines vegetation. But this hypothesis does not come close enough to the ultimate factor upon which depends the distribution of the plant societies. The ultimate cause of all this varied vegetation must be something more particular, something which will affect the individual plant. For such a region as this, this *something* must exist in the nature of the soil; climatic factors cannot explain differences in such a small area; and the historical factor is broad and general, like the physiographic one, and hence is not ultimate. That local differences in vegetation are due to soil factors has been practically proved before this, and the proof is strengthened by the present study. The physiographic hypothesis explains how it is that various soils may be physically and chemically different. But, after this is explained, the question with which we have to deal lies still untouched: *What is it in the nature of the soil which determines the distribution of our plant societies?*

Now, by "nature of the soil" two things may be denoted, and only two, *i. e.*, the *physical* nature and the *chemical* nature. But neither of these can influence the plant *per se*. Either one of the features may be effective, however, through soil water. Water is the only feature of the soil which comes in direct connection with the vitality of the plant. The chemical nature of the soil may be directly effective through the nature of the dissolved substances which enter the plant, or indirectly, through osmotic pressure. Its physical nature may be effective through the retention or non-retention in the soil of the water itself.

So far we may go *a priori;* beyond this, tests must be made. The nature of the soil water from various soils in various positions must be carefully determined. From these determinations will be shown how much truth or falsity there is in the explanation here offered, that the nature of the soil water is not usually a decisive factor for such a region as this.

Also, by careful tests the ability of various soils to retain water must be determined, and these determinations recorded with the vegetation found growing where the tests were made. Thus, and thus only, can the hypothesis here offered be tested, *i. e.*, the hypothesis that *the decisive factor in plant distribution over a small glaciated area is, in most cases, the moisture-retaining power* *of the soil.*[14] Mere field observations can neither destroy this hypothesis nor establish it.

On the other hand, the present series of observations seems to show that the historic factor may be a very important one in the distribution of the plant societies of Kent county, and the test of the hypothesis offered in this connection is to be obtained through observation and comparison, and through them alone.

It is hoped that in the future studies may be made of other areas lying north and south of this one, and the results carefully mapped and published. Emphasis is here laid on the map, for by it alone can a satisfactory comparison be instituted. Photographs are apt to be too superficial to be of any accurate use, though they would undoubtedly be valuable in connection with the map.

HULL BOTANICAL LABORATORY,
THE UNIVERSITY OF CHICAGO.

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[14] Similar conclusions to the one here expressed have been published by Mr. Bruncken. BRUNCKEN, E., Studies in plant distribution. 1. On the succession of forest types in the vicinity of Milwaukee. Bull. Wis. Nat. Hist. Society **2**: 17–28 1902.

BRIEFER ARTICLES

CONTRIBUTIONS TO THE BIOLOGY OF RHIZOBIA.

II. The motility of *Rhizobium mutabile.*

In previous communications[1] I stated that *Rhizobium mutabile* was absolutely non-motile. Further investigations have proved this to be incorrect. The former conclusion was based upon the observation of organisms grown in and upon neutral culture media. In neutral or very slightly alkaline solid beef gelatine or beef agar there is absolutely no active motion on the part of the organisms, whether cultures are recent or old. Nor do the organisms undergo any great change in size or form. As soon as the Rhizobia of sweet clover are transferred to acid media they undergo great changes in size and form. They are much smaller and more uniform in size. Branching forms are very rare, and the sporoids or highly refractive peripheral bodies are few and indistinct, but the cytoplasm is quite unequally distributed, as shown in the stained organisms. As a rule the cytoplasm is collected at either end, also at the middle, giving in the stained material the semblance of spores.

The motion is quite characteristic. It is a rapid, jerky, to-and-fro, and rotary motion and continues during the period of active septation, so that two or three incompletely divided organisms are seen moving about in the liquid media. If the medium is very slightly acid, only a few organisms show motility; or more correctly speaking, perhaps, in such media motion exists for a brief period only. In media which are quite acid most of the organisms show motion. In fact, the number of motile forms is proportionate to the degree of acidity. When motile forms are transferred to neutral or slightly alkaline solid media they develop into large, branching and non-branching, non-motile forms. Early in the experiments the presence of motile forms in what were supposed to be pure cultures of Rhizobia of sweet clover led me to believe I had to deal with contaminations with foreign bacteria. In fact, whole series of cultures were rejected as a consequence of this erroneous belief. The fact, however, that these cultures retained the general macroscopic characters of those which showed no motile forms led me to believe that they were, after all, not contaminations, but simply the product of a change in media, a conclusion fully verified by subsequent tests and experiments with media varying in degree of acidity. The discovery is also in harmony with recent observations of Arther Meyer,[2] and has further very important bearings upon my former conception of species of Rhizobia.[3] Rhizobia which I formerly described as *R. Frankii*, *R. Frankii minus*, and *R. Frankii majus* are in all probability merely motile forms of *R. mutabile*. But, as yet, the question of species and varieties of Rhizobia is far from settled. The more recent investigations point toward the existence of well-established varieties of one or at most a few species, of which *R. mutabile*[4] will unquestionably prove to be the chief or dominant type, as it occurs in the root tubercles of the greater number of leguminous plants.

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[1] Beitrag zur Kenntnis der Rhizobien: Ber. Deutsch. Bot. Gesell. **12**: 11–17. 1894. Contributions to the biology of Rhizobia, I. Rhizobium mutabile in artificial culture media. Bot. Gaz. **34**: 109–113. 1902.

R. mutabile cultures in acid solid media have a grayish tinge from the very first, which color becomes lighter, finally changing to brownish gray, and the cultures become less liquid and tenacious; otherwise they are as in neutral solid media. Rhizobia also tend toward motility in liquid neutral media. Observations lead to the conclusion that motility is the result of unfavorable conditions as to food supply, on the one hand, and an increased plasticity resulting from an abundance of liquid environment. Motility thus enables these organisms to compete more successfully in the struggle for existence. The motile forms are, in all probability, the normal, more highly specialized organisms, while the larger, branching, more polymorphous forms are degenerate types, adapted to a fixed and abundant food supply of the host plant. At least this seems to be a justifiable theoretical conclusion from the purely structural or anatomical point of view. Further experimentation is necessary to determine whether the motile forms are functionally more highly specialized, and whether these have a greater free nitrogen assimilating power or function.

The following is a summary of the experiments:

1. *Rhizobium mutabile* is non-motile in most neutral media, especially in solid neutral media.

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[2] Kurze Mittheilung über die Begeisselung der Bakterien. Centralbl. f. Bact. u. Parasit. **31**: 15. 1902.

[3] Observations on some American Rhizobia. Bull. Torr. Bot. Club **19**: 203–218. 1902.

[4] The *R. Leguminosarum* of Frank.

2. It is decidedly motile in acid media, whether these media are liquid or solid.

3. In acid media the growths become grayish to light gray and brownish gray in color.

4. Motile Rhizobia are much smaller and more uniform in size and form. — Albert Schneider, *Northwestern University, Chicago.*

CURRENT LITERATURE.

BOOK REVIEWS.

Books on trees.

THERE HAS LONG BEEN a demand for a nature-study book on trees that would contain something more than mere systematic studies. This demand Julia Ellen Rogers[1] has met in an admirable manner. This work is divided into four parts. In the first part (pp. 1–42), under the heading "outdoor studies with trees," the author writes in a very entertaining way on the life-history of the maple, how to tell the age of a tree, the battle among the twigs, thorns, and prickles, and other subjects. The second part (pp. 43–65) deals with the physiology of trees. The respiratory and photosynthetic processes are described simply and accurately; but under the heading "the sleep of trees" there are many unscientific and misleading statements. The heading itself illustrates this point. When we say that trees sleep we are getting out of the realm of facts into fancy. It is a question, of course, how far "fancy" can be carried into nature-study books. The line should be drawn so sharply that wrong inferences will not be made. The following sentence illustrates the point, and there are many more like it: "If the sky is overcast, the tree is drowsy; if rain sets in, it goes right off to sleep." We suppose that this is a reference to the photosynthetic process, but to the uninitiated this would convey the idea that the tree is actually drowsy in the same sense that animals are. A third section of the book (pp. 65–119) treats of the cultivation of trees. In a very clear and fascinating way the principles of landscape gardening are discussed, and one is told how to plant and trim trees. The forestry question, the farmer's wood lot, fruit trees, nursery trees, and diseases of trees — all subjects seldom mentioned in nature-study work — add materially to the value of the book. In the fourth part about 125 different kinds of trees are described. Too much cannot be said in praise of the workmanship of the book. The twenty-five full-page photogravures of entire trees and many half-tones of trunks and leaves are identical with those formerly issued by the publishers in the portfolio known as Series I, II, and III of *Typical forest trees*. While it might detract from the beauty of the book to number the illustrations, it would add much to its usefulness. *Among green trees* should be in the hands of all teachers of nature.

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[1] ROGERS, JULIA ELLEN, Among green trees. A guide to pleasant and profitable acquaintance with familiar trees. 8vo. pp. xxii + 202. *pls. 25. figs. 155*. Chicago: A. W. Mumford. 1902.

TWO RECENT BOOKS on forestry[2] will help greatly to popularize the knowledge of this subject, and too much cannot be said concerning their usefulness. The science of forestry has made such rapid progress during the last ten years that any work that discusses in a readable yet scientific way the subject in all its phases should find a ready sale among teachers of nature-study, woodland owners, beginners in forestry, and others. Both works have features in common, yet in a way they supplement each other.

ROTH presents the subject in the simplest possible manner. The relation of the forests to light, shade, soil, moisture, and temperature is discussed. The subject of "forestry" is treated under the following headings: the raising and keeping up the forest, its care, its use, and its business. A third part deals with the forest as a protective cover, the distribution of the forests in the United States, the wood and its properties, and closes with a valuable key to the common trees of the United States.

GIFFORD in the first part discusses the meaning of "forest" and "forestry," and treats of wood lots on farms, the forest canopy, the forest as a soil improver, the geographical distribution of forests, and barriers to forest extension. Part II treats of the formation and tending of forests. The author recognizes the intimate relations existing between the study of forestry and forest botany, especially plant ecology. In the third part the industrial phase of the subject is treated in a very interesting way, and in Part IV are brief descriptions of the location, areas, and special features of the forest reserves. Both books are well illustrated, mostly with half-tone reproductions of photographs.—H. N. WHITFORD.

Books for schools of pharmacy.

DR. ALBERT SCHNEIDER'S recent book[3] dealing with powdered vegetable drugs is the only work of its kind in English. In it 195 vegetable powders are described, 164 of them being figured. The first part treats of the color, odor, and test of vegetable drugs, the general histology of vegetable powders, equipment and methods of examination, parasites, adulteration, powdering and sifting, and includes two keys for identification. The second part contains a special description, with illustrations of the more important vegetable powders used in the United States.

DR. HENRY KRAEMER has prepared a book[4] intended to meet the botanical needs of students of pharmacy. The first part deals with plant morphology, under the two general headings of "the cell" and "the vegetative and reproductive parts of the plant." The treatment of these subjects is not from the modern biological standpoint, but rather from the standpoint of the details and terminology used by pharmacists. The second part treats of pharmacognosy, the two chapters being entitled "crude vegetable drugs" and "powdered vegetable drugs." The third part deals with reagents, and the fourth part consists of a set of seventeen plates.—J. M. C.

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[2] GIFFORD, JOHN, Practical forestry, 8vo. pp. xiv + 284. *figs. 35.* New York: D. Appleton & Co. 1902.

ROTH, FILIBERT, First book of forestry. 8vo. pp. ix + 281. *figs. 98.* Boston: Ginn & Co. 1902. 85c.

[3] SCHNEIDER, ALBERT, Powdered vegetable drugs. 8vo. pp. 323. Pittsburg: Calumet Publishing Co. 1902. $2.50.

[4] KRAEMER, HENRY, A course in botany and pharmacognosy. 8vo. pp. 384. Philadelphia: The author. 1902.

MINOR NOTICES.

A BULLETIN[5] of considerable economic importance has just been issued by the Bureau of Forestry. The work is divided into two parts. In the first part Hall describes several successful plantations in Kansas and discusses the important cultural points. In the second von Schrenk treats of the fungus diseases. The mycelium of *Polyporous versicolor* frequently destroys the heart wood of the tree. The bulletin is excellently illustrated.—H. N. WHITFORD.

E. S. BURGESS[6] has published a first volume of Aster studies, which is confined to the general historical treatment, leaving the description of species to a volume soon to follow. "The present volume traces the history of Aster to 1600, or through the continuance of the ancient monotype conception of Aster; that is, until Clusius's polytype conception came into full dominance as embodied in the series of Aster species set forth by him in 1601." The volume is really a sketch of the history of pre-Clusian botany, and is a very welcome addition to the botanical literature of English readers.—J. M. C.

A NEW FASCICLE[7] of Urban's *Symbolae Antillanae* has appeared. The first paper (pp. 161–274) is a presentation of Piperaceae by C. DECANDOLLE, 152 species being recognized, 27 (Piper 21, Peperomia 6) of which are described as new. The second paper (275–279) is a continuation of the description of new Hepaticae (10 in number) by F. STEPHANI. The third paper is a continuation of descriptions of new genera and species, by I. URBAN. The new species are 56 in number, and the new genera are *Chaenotheca* (Euphorbiaceae), *Krugiodendron* (Rhamnaceae), and *Neobuchia* (Bombacaceae).—J. M. C.

MILLSPAUGH[8] has published an account of the flora of St. Croix, the largest of the group of islands known as the Danish West Indies. A general account of the general ecological features and plant products of the island is followed by an interesting "Botanical history," which gives a very full account of botanical work on the island previous to the visit by the author himself. The list is based on Baron Eggers's well-known Flora of St. Croix and the Virgin Islands, 117 species being added. The total flora, as now known, numbers 1,029 species, 992 of which are vascular plants. It is pleasant to note that the author has succeeded in distributing his whole collection under published species, with the single exception of a species of Cordia.—J. M. C.

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[5] HALL, W. L., and VON SCHRENK, HERMANN. The hardy catalpa. Bureau Forestry, U. S. Dept. Agric. Bull. 37. pp. 58. *pls. 30.* 1902.

[6] BURGESS, E. S., History of pre-Clusian botany in its relation to Aster. Mem. Torr. Bot. Club **10**: 1–447. 1902.

[7] URBAN, IGNATIUS, Symbolae Antillanae seu fundamenta florae Indiae occidentalis. Vol. III. fasc. II. pp. 101–352. Leipzig: Gebrüder Bornträger. 1902. *M.* 10.80.

[8] MILLSPAUGH, C. F., Flora of the island of St. Croix. Field Columb. Mus. Publ. 68. Bot. Series **1**: 441–546. with map. 1902.

THE FIRST PART of Sargent's *Trees and Shrubs*[9] has appeared. The general scope of the work may be obtained from the title and from the preliminary announcement made in BOT. GAZ. 34: 388. 1902. Those acquainted with the *Silva* of Professor Sargent will recognize the same general style and arrangement of text and plates, the latter being reproductions of original drawings made by C. E. Faxon, probably the most skilful and experienced botanical draftsman in America. This first part contains descriptions and illustrations of *Juglans mexicana* S. Wats., seven new species of Crataegus (*C. durobrivensis* Sarg., *C. Laneyi* Sarg., *C. Coleae* Sarg., *C. maloides* Sarg., *C. luculenta* Sarg., *C. fruticosa* Sarg., *C. paludosa* Sarg.), *Eupatorium Loesenerii* Robinson, *Senecio Robinsonianus* Greenm., *Styrax Ramirezii* Greenm., *Faxonanthus Pringlei* Greenm. (a new Mexican genus, singularly described with no statement as to its family), *Ehretia viscosa* Fernald, *Berberis Sieboldi* Miq., *Ilex serrata* Thumb., *Acer capillipes* Maxim., *A. Tschonoskii* Maxim., *Malus Halliana* Koehne, *Viburnum Wrightii* Miq., four new species of Lonicera (*L. saccata* Rehd., *L. Koehneana* Rehd., *L. ferruginea* Rehd., *L. arizonica* Rehd.), *L. Griffithii* Hook. f. and Thoms., *Enkianthus subsessilis* Makino.—J. M. C.

NOTES FOR STUDENTS.

MASSART has published a preliminary work[10] on the influence of pollination on the growth of the fruit of Cucurbitaceae. He finds that the initial stimulus to growth is from the pollen, and is perceptible when killed pollen is applied to the stigma. The further growth of the fruit is dependent on a stimulus from the "fertilized ovules," whose transmission is limited, so that cavities are formed when no embryos are formed in some chambers of the fruit.—E.B. COPELAND.

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[9] SARGENT, CHARLES SPRAGUE, Trees and shrubs, illustrations of new or little known ligneous plants prepared chiefly from material at the Arnold Arboretum of Harvard University. Part I. Boston and New York: Houghton, Mifflin & Co. 1902. $5. net.

[10] MASSART, I., Sur la pollination sous fécondation. Bull. Jard. Bot. État. Bruxelles 1: fasc. 3. pp. 7. 1902.

FREDERIC E. CLEMENTS has published[11] a paper entitled "Greek and Latin in biological nomenclature." Its purpose may be expressed in the following quotation: "The following treatise is intended to serve as a compendium of the principles of word-formation in Greek and Latin of sufficient thoroughness to enable the biologist to construct in proper manner any derivative desired. Further than this, various unfortunate usages which have obtained in nomenclature and the many types of malformations will be considered in detail, and suggestions will be made for their correction or elimination."—J. M. C.

FERRARIS[12] has undertaken a morphological study of the Iridaceae, his first paper dealing with Romulea. The archesporial cell gives rise to a row of three megaspores, the innermost of which functions. The synergids show a prominent development of the filiform apparatus. The three antipodals become very large and send out beaks into the projection of chalazal tissue that extends into the antipodal extremity of the sac. The sac finally completely replaces the nucellus, the extremity being freely exposed in the micropyle. The remaining phenomena recorded are those common among monocotyledons.—J. M. C.

IN HIS STUDY of the parasitism of *Buckleya Quadriala*, Kusano[13] reaches the following conclusions: The haustorium is provided with a cambium ring between its cortical and axial parts which joins that of both the host and the mother-root; the form and structure of the haustorium change with age; it possesses medullary rays, but the existence of sieve tubes could not be determined definitely; the sucker, easily distinguishable in the younger stage, loses its distinctiveness from the part behind after a certain amount of growth; as long as the host root is alive the haustorium may be active and can maintain its life during many years.—J. M. C.

A PAPER by Neubert[14] on the nutations of the cotyledon of Allium comes to these conclusions: (1) the formation of the characteristic knee is automatic, though influenced by negative geotropism and the consistency of the earth; (2) the elimination of the curve is also chiefly automatic, but here too gravity has some directive influence; (3) the formation of the protuberance on the knee is dependent on darkness and friction. Neubert seems not to know of the existence of my work on the geotropism of these cotyledons,[15] nor of

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[11] University Studies, Univ. Nebr. 3: 1–86. 1902.

[12] FERRARIS, TEODORO, Ricerche embriologiche sulle Iridacee. I. Embriologia del G. *Romulea* Maratti. Ann. R. Istit. Bot. Roma 9: 221–241. *pls. 6–7.* 1902.

[13] KUSANO, S., Studies on the parisitism of *Buckleya Quadriala* B. et H., a santalaceous parasite, and on the structure of its haustorium. Jour. Coll. Sci. Imp. Univ. Tokyo 17: article 10, pp. 42. *pl. 1.* 1902.

[14] NEUBERT, R., Untersuchungen über die Nutationskrümmungen des Keimblattes von Allium. Jahrb. Wiss. Bot. 38: 119–145. 1902.

[15] COPELAND, E. B., Positive geotropism in the hypocotyl or cotyledon. BOT. GAZ. 31: 410–421. 1901.

Noll's fine work on Cucurbita,[16] which in essentials antedates about all that might otherwise be novel or valuable in this paper from the Leipzig laboratory.— E. B. COPELAND.

HARTLEY,[17] in studying the effects of premature pollination in tobacco, cotton, and tomato, has reached the following definite conclusions: "that the application of good tobacco pollen to immature tobacco pistils causes the flowers so treated to fall from the plant because of the growth of pollen tubes into their ovaries; that tobacco and tomato plants sometimes set and ripen fruits without the flowers having received any pollen, and that such fruits contain no germinative seeds; and that but few fruits will be obtained by the pollination of immature cotton and tomato pistils, but that good percentages may be obtained if the pollination is performed when the pistils are receptive."—J. M. C.

IN A SHORT PAPER on the controlling factors in the direction of branch growth, Wiesner[18] suggests that the position of lateral branches may be a resultant due to the action of negative geotropism on the one hand and to epinasty on the other. As the intensity of epinasty varies with age in some forms, changes in direction which occur as a branch matures may often be explained on this ground, the intensity of negative geotropism being constant as long as growth continues. Since practically nothing is known as to the true nature of epinasty, and since quantitative measurement of geotropic reaction is at least very difficult, it seems to us that such conclusions as the above can be of little avail in advancing true physiology.—BURTON E. LIVINGSTON.

WEISS[19] has elucidated in an interesting way the structure of the tracheary branches first described by Renault as occurring in stigmarian rootlets. He shows that these tracheary strands occur in typical monarchous rootlets. They run from the protoxylem group across the generally lacunar middle cortex of the root and end in a special organ composed of large tracheary elements in the outer cortex. On account of the absence of dichotomy, he draws the conclusion that they cannot be strands belonging to branch-rootlets, but rather represent special water-absorbing organs rendered necessary on account of the usually almost complete separation of the central cylinder of the stigmarian rootlet from the outer cortex.— E. C. JEFFREY.

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[16] NOLL, F., Zur Keimungsphysiologie der Cucurbitaceen. Landw. Jahrb. Ergänzungsband I. 1901.

[17] HARTLEY, CHARLES P., injurious effects of premature pollination. Bull. 22. Bureau of Plant Industry, U. S. Department of Agriculture. Oct. 4. 1902.

[18] WIESNER, J., Regulirung der Zweigrichtung durch "variable Epinastie." Ber. Deutsch. Bot. Gesell. **20**: 321–327. 1902.

[19] WEISS, F. E., The vascular branches of stigmarian rootlets. Ann. Botany **16**: 559–574. *pl. 26.* 1902.

KRAEMER,[20] in his study of the structure of the starch grain and the cell-wall, has discovered that certain appearances described by various authors as indicating a continuity of protoplasm are due to a peculiarity in the structure of the cell-wall, which is made manifest by the reagents employed, and which resembles the structure of the starch grain. He also calls attention to the fact that investigators have generally fallen into the error of supposing that a certain aniline dye could be regarded as a differential stain for protoplasm, whereas the fact is that many colloidal carbohydrates, as mucilage and pectin, and oils and other substances as well, take up these stains. If the substance in the cell-wall which takes up the stain is protoplasm, what is it in the starch grain?—J. M. C.

STORER[21] adds very materially to our knowledge of mannan as a stored food-stuff in plants by a series of notes on the detection of its hydrolysis product, mannose. A long experience in the study of these substances gives him the right to speak authoritatively on the methods best adapted to their identification and estimation. The methods are clearly described and the difficulties fully discussed. He finds abundance of mannan in the following plant tissues: date stones, ivory nut, flesh of ripe cocoanut, seeds of *Trifolium repens*, and the wood of *Pinus Strobus*, *P. rigida*, *Picea excelsa*, *Larix leptolepis*, *Tsuga canadensis*, *Juniperus virginiana*, and *Chamaecyparis sphaeroidea*. Smaller amounts of mannan are contained in a number of other tissues tested.—BURTON E. LIVINGSTON.

UNDERWOOD[22] has given a surprising account of the genus Gymnogramme as presented in Hooker's *Synopsis Filicum*. So far from being a natural assemblage, it contains among its species a number of generic groups, several of which bear no close phylogenetic relations to the others or to each other, some even belonging to different tribes. Some of these genera submerged under Gymnogramme are related to the Polypodieae, others to the Aspidieae, one possibly to the Vittarieae, but more are distinctly related to the Asplenieae. The name Gymnogramme being a typonym of the monotypic Gymnopteris, established thirteen years earlier, disappears from botanical nomenclature. The two species occurring within the limits of the United States heretofore referred to Gymnogramme represent two distinct genera, *Ceropteris* Link and *Bommeria* Fourn.—J. M. C.

MENDEL[23] has investigated the products formed by the action of papain, the proteolytic enzyme of the fruit of *Carica papaya*, upon proteids, with the following results: Papain is active in both acid and alkaline media, forming caseoses and casein peptones which closely resemble these bodies as they are produced in gastric digestion. Thus this enzyme is like pepsin as to the products of its action, but unlike it in that pepsin cannot act in an alkaline medium. Trypsin, as is well known, develops its action in an alkaline medium as well as in an acid one, but its products are quite different from those of pepsin, being mainly leucin, tyrosin, and tryptophan, none of which were found among the products of papain digestion. Mendel concludes, therefore, that papain must be regarded as belonging to a class quite distinct from that of either pepsin or trypsin.— BURTON E. LIVINGSTON.

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[20] KRAEMER, HENRY, On the continuity of protoplasm. Proc. Amer. Phil. Soc. **41**: 174–180. *pls. 21–22.* 1902.

[21] STORER, F. H., Testing for mannose. Bull. Bussey Inst. **3**: 13–45. 1902.

[22] UNDERWOOD, L. M., American ferns. IV. The genus Gymnogramme of the Synopsis Filicum. Bull. Tor. Bot. Club **29**: 617–634. 1902.

[23] MENDEL, L. B., Observations on vegetable proteolytic enzymes, with special reference to papain. Am. Jour. Med. Sci. pp. 9. (Aug.) 1902.

PALLADIN[24] has added to his former researches concerning the generation of chlorophyll in etiolated leaves. He had already shown that such leaves, when cut and exposed to sunlight, fail to become green unless they contain carbohydrate material or are supplied with it from a solution into which they dip.[25] Moreover, not only can solutions of saccharose and glucose bring about this effect, but other carbohydrates are also available, *e. g.*, raffinose, fructose, maltose, and even glycerin.[26] In the present study he has been able to show that the formation of chlorophyll in such leaves depends upon the concentration of the solution, which may be either too weak or too strong to produce the response. The optimum greening is in a medium concentration. That strong solutions of saccharose can inhibit greening is explained by the fact that they greatly retard oxidation; the process of chlorophyll formation is known to b, at least in part, one of oxidation.— BURTON E. LIVINGSTON.

IN THE FOURTH of his studies on the genus Selaginella, Harvey-Gibson[27] discusses the anatomy and development of the root. He concludes that the so-called rhizophores which are characteristic of certain species of Selaginella do not possess the morphological value of caulomes, but are merely the aerial portions of roots. He points out their close relation to branches, a correlation which, by the way, presents a striking parallel to the condition found in Equisetum and the other Lycopsida. The author suggests that, in those cases where a leafy branch grows out from the situs of a rhizophore, there is really present a branch-root combination in which the root has been suppressed. The internal structure of the typical root and the rhizophore is the same, both being monarchous and possessing a well-marked endodermis. The xylem of the root is generally perixylic, but in the rhizophoric portions of the root in *S. Krausiana*, *S. delicatissima*, and *S. Poulteri*, it is centroxylic.— E. C. JEFFREY.

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[24] PALLADIN, W., Einfluss der concentration der Lösungen auf die Chlorophyllbildung in etiolirten Blättern. Ber. Deutsch. Bot. Gesell. **20**: 224–228. 1902.

[25] PALLADIN, W., Ergrünen und Wachsthum der Etiolirten Blätter. Ber. Deutsch. Bot. Gesell. **9**: 429. 1891.

[26] PALLADIN, W., Recherches sur la formation de la chlorophylle dans des plantes. Rev. Gén. Bot. **9**: 385. 1891.

[27] HARVEY GIBSON, R. J., Contributions towards a knowledge of the anatomy of the genus Selaginella. Ann. Botany **16**: 449–466. *pls. 20–21.* 1902.

TREUB[28] has concluded that *Ficus hirta* produces parthenogenetic embryos, and that this may be true of all the species of Ficus. Although pollen grains on the stigma were observed to put out tubes, no tubes could be found penetrating toward the sac or within the sac; and yet there was an abundance of developing embryos, from the undivided egg to a many-celled stage. Treub supports this argument for parthenogenesis by the feeble development of endosperm, and the poorly organized egg apparatus, especially the synergids; but neither point seems to be well taken. In fact, the evidence of parthenogenesis in this case is the repeated failure to find any trace of pollen tubes where they ought to be in case fertilization occurs The suggestion is made that the stimulus to segmentation in this case is the puncture of the pollinating Blastophaga. Since there are only three recorded cases of parthenogenesis among angiosperms, there is no reason why the author should mention Juel's Antennaria and Murbeck's Alchemilla and omit Overton's Thalictrum.— J. M. C.

SHOEMAKER[29] has obtained some interesting results from a study of *Hamamelis virginiana*. In each anther two sporangia appear instead of the usual four, and dehiscence is by means of a door-like valve hinged on the side towards the carpel. The pollen grains show great resistance to low temperature; some were observed to send out tubes after a week of cold weather during which the temperature was at times as low as −15°. Perhaps the most interesting fact is the long period between pollination and fertilization, putting Hamamelis in a category with the Amentiferae in this regard. Pollination occurs from October to December; and the tubes at once enter the nucellus and grow rapidly until cold weather. Live tubes were found in January and February safely embedded in the hairy part of the carpel. In the spring growth is resumed and fertilization occurs about the middle of May, five to seven months after pollination. The endosperm nucleus begins to divide after fertilization, and walls begin to appear at about the 12-nucleate stage, the walls appearing first at the bottom of the sac.— J. M. C.

MASSART[30] has issued reprints of three papers on irritability. The first and longest deals with positions of equilibrium toward stimuli acting alone or together. Massart assumes an actual or possible transmission of a stimulus in many cases where it has yet to be demonstrated; the same experiments as many of his satisfied the reviewer[31] that no transmission occurs. Massart's method of experiment deserves imitation; his cultures were photographed at intervals on the same plate, without moving the camera. For the many individual results the paper must of course be read, but it may be noted here that stems and roots were found most irritable geotropically when horizontal. In the second paper it is shown that the secondary thickening of stems and nourishing roots of Ficus species climbing by clinging roots is localized on the less illuminated side. In Massart's terminology this is cataphotanisopachynosis, which tells the story "in a word." Several other instances of unequal thickening (anisopachynosis) are described and figured. The third paper treats of the aerial roots of Ficus. There are three kinds, and the geo-, photo-, and haptoneism (origin) and -tropism of each is described.— E. B. COPELAND.

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[28] TREUB, M., L'organe femelle at l'embryogénèse dans le *Ficus hirta* Vahl. Ann. Jard. Bot. Buitenzorg II. **3**:124–157. *pls. 16-25.* 1902.

[29] SHOEMAKER, D. N., Notes on the development of *Hamamelis virginiana* L. Johns Hopkins Univ. Circ. **21**:86–87. 1902.

[30] MASSART, I., Sur l'irritabilité des plants supérieures. I, II, III. Acad. Belgium Mém. Cour. et autres Mém. **62**: reprint, 60 pp. 1902.

PURE CULTURES of *Stichococcus bacillaris* have been again obtained by Matruchot and Molliard,[32] who have carried on some rather extensive experiments upon this alga when grown in various media. Although it does not need large amounts of oxygen for its development, it is not a true anaerobe. The glucoses appear to be the best food tested; dextrine, gum, glycerin, and mannite are all foods, but not as available as the glucoses; while the saccharoses (cane sugar, lactose, maltose) are hardly available at all. Salts of ammonium are foods, but nitrates are not assimilated. Several different concentrations of glucose and saccharose were tested. In stronger solutions the short diameter of the cells is diminished, the cells thus becoming somewhat longer in proportion to their width. It is to be regretted that the authors persist in the use of the percentage system in making up their solutions, and that they have made no observations on the influence of osmotic pressure *per se*. The plant develops normally in the dark. Some studies on the changes in the nucleus according to the culture medium were also made. Careful *quantitative* work in such researches as this would probably advance our knowledge of physiology much more rapidly than this sort of qualitative observation.— BURTON E. LIVINGSTON.

THE DEVELOPMENT of swarm-spores in Hydrodictyon is described in great detail in a recent paper by Timberlake.[33] The nucleus resembles that of the higher plants in the behavior of its chromatin, and also in having a well-defined nuclear membrane and a nucleolus. The spindle is bipolar, and at the poles there are sharply defined bodies which the writer interprets — and doubtless correctly — as centrosomes. When spores are about to be formed, a progressive cleavage takes place in the multinucleate protoplasm until the

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[31] BOT. GAZ. **29**: 187–188. 1900.

[32] MATRUCHOT, L. et MOLLIARD M., Variations d'une algue verte sous l'influence du milieu nutritif. Rev. Gen. Bot. **40**: 114–130, 254–268, 316–332. 1902.

[33] TIMBERLAKE, H. G., Development and structure of the swarm-spores of Hydrodictyon. Trans. Wis. Acad. Sci. **13**: 486–522. *pls. 29–30.* 1902.

protoplasm becomes segmented into small portions, each containing a single nucleus. This segmentation is radically different from that which takes place in the endosperm of higher plants. It is entirely independent of nuclear divisions, and is accomplished by pairs of furrows pushing into the protoplasm from opposite directions, and not by intraplasmic vacuoles as described by Klebs. The spores have two cilia attached to a small, deeply staining granule just beneath the plasma membrane. It is too early even to suggest that this granule may be homologous with the blepharoplast of higher forms. Two delicate threads connect the granule with the nucleus. The cilia themselves stain like spindle fibers. After the spores come to rest, the pyrenoid, which disappears at the beginning of segmentation, again becomes visible. There is no organized chromatophore.—C. J. CHAMBERLAIN.

VALUABLE ADDITIONS to our knowledge of the process of respiration are outlined by Kostytschew[34] in a preliminary paper from the St. Petersburg laboratory. He has studied the effect of the nutrient medium upon intramolecular respiration in *Mucor stolonifer* and *Aspergillus niger*. The plants were grown in chambers closed from the air, through which a stream of pure nitrogen was passed during the entire experiment. The intensity of intramolecular respiration is measured in terms of the amount of CO_2 given off per gram of dry substance. Some of the results of the study are as follows: Intramolecular respiration occurs in pure water and in a variety of organic substances. In sugar, peptone, and acetates the intensity of the process is greater than in pure water, while in glycerin, free acetic acid, and quinic acid it equals or falls below that in water. In solutions of acetates *Mucor stolonifer* produces much oxalic acid, but in sugar solutions this substance is almost wholly lacking. Presence of zinc salts increases the amount of oxalic acid produced by Aspergillus. Low concentrations of the medium give greater respiratory intensity than higher ones, the optimum concentration being about two per cent. The author believes the last to be a purely osmotic effect, but the molecular weights of the substances used are so different that it is difficult to consider this proved until it is tested with solutions made up by modern methods.—BURTON E. LIVINGSTON.

DICOTYLEDONS with only one cotyledon still offer a problem to be solved. The latest paper on the subject deals with several of these so-called "pseudomonocotyledons."[35] The "pseudomonocotyledons" studied were *Eranthis hiemalis*, *Corydalis cava*, *Ranunculus Ficaria*, and *Bunium* (*Carum*) *Bulbocastanum*. *Corydalis nobilis* and *C. lutea*, forms which always have two cotyledons, were studied for comparison. *Cyclamen persicum* was also studied on account of its first leaf, which has sometimes been mistaken for a cotyledon. In *Ranunculus Ficaria* there is hardly a trace of a second cotyledon. In *Corydalis cava* the prominent cotyledon gradually assumes a terminal position, causing a displacement of the stem tip so that it appears lateral. Occasionally there is a slight protuberance which might or might not be the rudiment of the other cotyledon. In Bunium also it was doubtful whether a slight protuberance might be interpreted as the rudiment of the missing cotyledon. In *Cyclamen persicum* embryos in the ripe seed show no trace of a second cotyledon. Attempts to induce the development of the missing cotyledon by removing the prominent one gave only negative results. The paper would doubtless have been more complete had it not been for the early death of the writer. The experimental part certainly deserves another trial. Bunium, which Schmid regarded as the form most favorable for experiment, was not investigated, because material in the proper stages was not available.—C. J. CHAMBERLAIN.

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[34] KOSTYTSCHEW, S. Der Einfluss des Substrates auf die anaerobe Athmung der Schimmelpilze. Ber. Deutsch. Bot. Gesell. **20**: 327–334. 1902.

[35] SCHMID, B., Beiträge zur Embryo-Entwickelung einiger Dicotyledonen. Bot. Zeit. **60**: 207–230. *pls. 8–10.* 1902.

IN A RECENT SERIES of experiments upon the influence of diminished atmospheric pressure upon the photosynthetic process, Friedel[36] has discovered a curious condition of affairs. Young leaves of *Euonymus japonicus*, *Ruscus aculeatus*, and *Ligustrum japonicum*, and entire plants of *Lepidium sativum* were used. A diminution in atmospheric pressure produces first a decrease in the intensity of photosynthesis; then this intensity passes through a minimum, increases again to a maximum, and at last decreases to zero when a pressure of about one-tenth of an atmosphere has been reached. The minimum is from 0.4 to 0.6 of the normal intensity and is reached at a pressure between 0.4 and 0.5 of the normal atmospheric pressure. The maximum intensity (in Ruscus it is more than double the normal, in Ligustrum it is 0.7 of the normal) is reached at a pressure of 0.14 to 0.22 atmosphere. The author presents evidence that this is due to the joint action of two causes: (1) a decrease in the partial pressure of CO_2 brings about a fall in the intensity of photosynthesis, while (2) a decrease in the total atmospheric pressure occasions a rise. Changes in the partial pressure of oxygen alone have no effect. Also, an increase in the volume of the air in the experiment chamber causes a rise in photosynthetic activity. What may be the exact meaning of these facts it is impossible to conjecture. Perhaps these facts have some connection with the reputedly greater photosynthetic activity of alpine plants as compared with that of lowland forms.—BURTON E. LIVINGSTON.

MCKENNEY[37] has been conducting experiments upon the conditions of light production in luminous bacteria. His own summary of the chief results is as follows: (1) all acids are injurious to light production; a slight excess of alkali is even more injurious than a slight excess of an acid; (2) the temperature limits for light emission are within those necessary for growth; (3) change of temperature, either sudden or gradual, is without effect on luminescence, i. e., does not stimulate; (4) there is no luminescence at or below 0°; (5) exposures to temperatures above the growth maximum are highly injurious to the power of light production, while exposure to very low temperatures seems to serve as a stimulus to light production; (6) *Bacillus phosphorescens* is capable of adapting itself to high temperatures, producing a race capable of light production at 35°, which is 5° above the normal maximum for luminescence; (7) a certain degree of continued illumination is without effect, and it is possible for the bacteria to live their entire lives in the dark and yet emit a brilliant light; (8) ether acts as a narcotic, preventing luminescence, but not growth and multiplication; (9) it is possible to develop a race of bacteria so immune to the action of small amounts of ether as to be still luminous in its presence; (10) peptone or related protein is required for the nutrition of luminous bacteria; (11) dextrose and certain of the higher sugars may be utilized advantageously by *B. phosphorescens;* (12) either sodium or magnesium is required for growth, and especially for light production; minimum, maximum, and optimum amounts of sodium are observed for growth and luminescence; (13) potassium, ammonium, lithium, rubidium, calcium, barium, and strontium cannot replace sodium (or magnesium).—J. M. C.

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[36] FRIEDEL, JEAN, L'assimilation chlorophyllienne aux pressions inférieures a la pression atmosphérique. Rev. Gen Bot. **40**: 337–355, 369–390. 1902.

[37] MCKENNEY, R. E. B., Observations on the conditions of light production in luminous bacteria. Proc. Biol. Soc. Washington **15**: 213–234. 1902.

STRASBURGER[38] has recently published a very complete account of the morphology and biology of *Ceratophyllum submersum*, and has made this work the occasion for some interesting and important remarks upon phylogeny. As is well known, the pollen is discharged and pollination takes place under water. The anthers ripen in succession and an enormous quantity of pollen is produced, so that, in spite of the inevitable loss, most of the ovules produce seeds. The embryo sac shows nothing unusual in its structure. Double fertilization was observed and the chromosomes, twelve in the gametophyte and twenty-four in the sporophyte, were counted. The formation of the endosperm is peculiar. At the first division of the endosperm nucleus a transverse wall is formed, dividing the sac into two chambers, of which the one nearest the chalaza does not divide again; the other divides, and here again only the cell next the micropyle divides again. This method continues for a few divisions, and then walls are formed in three planes, giving rise to a small-celled tissue near the embryo, and a filament of a single row of cells at the chalazal end of the sac. In early stages the embryo is spherical, and there is no suspensor. At a later stage the embryo bears a striking resemblance to that of Nelumbo which Lyon described as having but one cotyledon and a lateral stem tip. Strasburger finds two cotyledons in Ceratophyllum, and after examining Nelumbo decides that here also there are two cotyledons, and that the apparently lateral origin of the stem tip is due to displacement. In Ceratophyllum not even the rudiment of a primary root is formed. The absence of a differentiated tissue in the cotyledon Lyon regards as a character not found in dicotyledons. The same structure appears in Ceratophyllum and Strasburger believes it is due to the fact that there is no primary root, the first functioning root coming from the stem above the cotyledon, practically the same condition as in Nelumbo; for, while Nelumbo has the rudiment of a primary root, it does not function, the first functional roots appearing as in Ceratophyllum. This, like the general reduction of the vascular system is regarded as an extreme adaptation to the water habit. Through such extreme adaptation the specific characters which indicate the place of the plant in the natural system are often obscured or even suppressed.

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[38] STRASBURGER, E., Ein Beitrag zur Kenntniss von *Ceratophyllum submersum* und phylogenetische Erörterungen. Jahrb. Wiss. Bot. 37: 477–526. *pls. 9–11.* 1902.

The latter part of the paper is devoted to a discussion of homology and phylogeny. Nothing but a careful reading of the entire paper could give an adequate idea of the views presented, but a few points may be mentioned. In establishing a natural system of organisms morphology will constantly be the guide, while to physiology will fall the task of clearing up the causes of influences, and of bringing definite forms and structures into relation to function. Natural selection has been overestimated; its function appears to be only that of removing the less valuable forms provided by mutation and direct influence. As Hertwig says, there are many cases in which the sequence of stages in ontogenetic development are caused by general laws of the development of living substance, but in many cases, like the water ferns, recapitulation is evident.— C. J. CHAMBERLAIN.

ITEMS OF TAXONOMIC INTEREST are as follows: M. L. FERNALD (Rhodora **4**: 213–216. 1902) has described a new variety (*obtusifolia*) of *Glaux maritima*.— PH. VAN TIEGHEM (Jour. Botanique **16**: 289–291. 1902) has described another new genus (*Periblepharis*) of Luxembourgiaceae.— L. M. UNDERWOOD (Torreya **2**: 172–173. 1902) has described 2 new species of Selaginella from North Carolina.—E. L. GREENE (Pittonia **5**: 57–106. 1902), in a fascicle of new Compositae, has described new species of Gaillardia (2), Laciniaria (2), Erigeron (2), and Chrysothamnus (12); has described 5 new species of Apocynum and 10 new species of Eriogonum; has revised the genus Euthamia to include 14 new species; has described 15 new species of Monardella, and 15 new species of Viola.—THEO. HOLM (Am. Jour. Sci. IV. **14**: 417–425. 1902) has described 3 new segregates of *Carex Tolmiei* Boott.— C. V. PIPER (Bull. Torr. Bot. Club **29**: 642–646. 1902), in his seventh paper on new and noteworthy northwestern plants, has described new species of Lupinus, Arctostaphylos, Phlox, Allocarya, Mertensia, Lonicera, and Aster (5).— In the publication of the Chinese *Plantae Bodinierianae*, MM. LÉVEILLÉ and EUG. VANIOT (Bull. Acad. Internat. Géog. Bot. **11**: 338–344. 1902) have described 5 new species of Polygonum, and EUG. VANIOT (*idem* 345–351) has described 8 new species of Senecio.—In a fourth paper entitled "Descriptions of American Uredineae," J. C. ARTHUR and E. W. D. HOLWAY (Bull. Lab. Nat. Hist. Univ. Iowa **5**: 311–334. *pls. 1–9.* 1902) have presented the American rusts upon Agrostideae and Chlorideae, including 16 species, one of which is new. In only one species (*P. fraxinata*) is the full cycle of development traced.—C. S. SARGENT (Trees and shrubs, Part I. 1902) has published descriptions of 7 new species of Crataegus, a new Mexican genus (*Faxonanthus*, family not stated) by Greenman, a new Ehretia by Fernald, and 4 new species of Lonicera by Rehder.—A. ENGLER (Bot. Jahrb. **36**: 1–208. 1902), in his 24th contribution to the flora of Africa, has published an account of the plankton (Cyanophyceae and Chlorophyceae) of Nyassa and of other African lakes, by W. SCHMIDLE; a new genus (*Cycloschizon*) of Hysteriaceae by P. HENNINGS; 9 new species of Panicum by R. PILGER; 32 new species of Orchidaceae by F. KRÄNZLIN; a revision of Dichapetalaceae (24 n. spp.) by A. ENGLER and W. RUHLAND; a revision of Lentibulariaceae (51 species, including 10 n. spp. of Utricularia) by F. KAMIENSKI; a second paper on Moraceae (12 n. spp.), Urticaceae (14 n. spp.), Proteaceae (3 n. spp.), Violaceae (23 n. spp. of Rinorea), all by A. ENGLER; a third paper on Leguminosae (44 n. spp., the new genera being *Pseudoprosopis*, *Bussea*, *Dicraeopetalum*, *Pseudocadia*, and *Adenodolichos*) by H. HARMS; a second paper on Araliaceae (1 n. sp.) by H. HARMS; a sixth paper on Acanthaceae (21 n. spp.) by G. LINDAU; Dilleniaceae (7 n. spp.) by E. GILG; and the beginning of Capparidaceae by E. GILG.—A. ZAHLBRUCKNER (Beih. Bot. Centrabl. **13**: 11–163. 1902) has described 19 new Californian lichens collected by Dr. H. E. Hasse of Los Angeles, among them a new genus (*Hassea*).—I. URBAN (Symbolae Antillanae **3**: 280–352. 1902), in describing 56 new species of West Indian plants, has established new genera in Euphorbiaceae (*Chaenotheca*), Rhamnaceae (*Krugiodendron*), and Bombacaceae (*Neobuchia*).—F. STEPHANI (Bull. Herb. Boiss. II. **2**: 969–987. 1902) has described 16 new species of Plagiochila from Africa.—F. N. WILLIAMS (*idem* 1019–1021) has discovered that the puzzling Mexican *Abasoloa Taboarda* Llave & Lexarza is *Sabazia Michoacana* Robinson.—J. M. C.

RECENT TERATOLOGICAL LITERATURE.—DE CANDOLLE[39] presents a second contribution to our knowledge of the ascidia of Ficus, basing his observations on living material from the Botanical Gardens at Calcutta, where there are two young trees grown from cuttings from an older tree in the vicinity of Calcutta. The leaves of these trees he designates as hypoascidia, the inner surface of the ascidium representing the ventral surface of the leaf, as contrasted with epiascidia, the usual form in which the inner surface is homologous with the dorsal surface of the leaf.

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[39] DE CANDOLLE, C., Nouvelle étude des Hypoascidies de Ficus. Bull. Herb. Boissier II. **2**: 753–762. *pls. 8–9.* 1902.

Stomata, corresponding in structure with those of *Ficus bengalensis*, with which they were compared, were abundant on the internal surface of the ascidium, but absent on the external surface, which contains the palisade tissue. Furthermore, the outer surface (the dorsal surface of the leaf) of the ascidium is provided with a hypodermis, which is interrupted here and there by a large cystolith-containing cell, neither of which is found on the inner surface. In addition to the normal form, two leaves were found in which two pouches were formed, one on either side of the midrib, by the coalescing of the inner surface of the ascidium with the midrib along a line opposite to the midrib. The course of the vascular system in both forms is described. Their ontogeny was also studied, the first indication of the formation of an ascidium being found in a leaf about 1.5^{mm} in length, while at a length of 4^{mm} the complete structure was found. The ascidium results from the formation of the lamina completely around the end of the petiole, and corresponds, except that it takes place in an inverse manner, with the development of ordinary epiascidia. As to whether the phenomenon is teratological in nature or whether the trees are to be regarded as representing a distinct species cannot yet be decided. The great age of the phenomenon would be indicated by the legends concerning the miraculous transformation of the leaves of an old banyan (*F. bengalensis*) from which these trees descended.

PENZIG[40] has also published teratological notes, most of which deal with foliar ascidia. In *Smilax aspera* he describes epiascidia in which the coalescence of the foliar margins occurs toward the apex instead of the base of the leaf. He designates this form as apical epiascidium, in contradistinction to the very common basal epiascidium. Apical epiascidia have hitherto been recorded in teratological literature in *Tulipa Gesneriana*. In *Carica Papaya* he figures and describes a large series of interesting malformations in accessory stalked laminae produced from the center of the leaves. This phenomenon in itself is so rare as to be of great interest, but this interest is greatly increased by the extraordinary conformation of the lamina of the accessory leaf. In the simplest form the leaf is a simple, basal epiascidium; in more frequent cases the modification represents twin ascidia (diplascidia), that is, one to the right and the other to the left of the midrib. Similar ascidia are frequent in *Saxifraga crassifolia*. The midrib may become free from the ventral surface or extend through the lower somewhat peltate portion of the lamina, bearing above a more or less completely developed ascidium. Several more or less perfectly formed ascidia, sometimes as many as four, may occur on the same midrib, in which case the forms alternate, a hypoascidium following an epiascidium and *vice versa*. The part of the paper dealing with ascidia is illustrated by forty well chosen and executed figures.

DISCHIDIA RAFFLESIANA has attracted the attention of several writers, as Wallich, Griffiths, Beccari, Treub, and Groom. Since 1890 it has been grown with success at Kew. In 1893 Dr. Scott and Miss Sargant[41] published a study of the pitchers of this plant, basing their observations on the Kew material. Thistleton-Dyer adds a note[42] based on teratological material, "atavistic forms," as he designates them, which appeared after some ten years cultivation. The pitchers are morphologically leaves, the inner surface corresponding to the lower surface of the normal foliage leaf. The abnormal forms represent a series of transitions from a normal leaf to the pitcher by an increasing concavity of the under surface. The pitchers in the abnormal material differ, however, from the fully developed organ in the open mouth, uninflexed margins, and small size. Unless it be in one case, no indication was found of any such transition stage having been observed in nature. The production of pitchers is not a general characteristic of Dischidia, only a small part of the whole number of species having this habit. He considers that there can now be little doubt that the pitchers have as an ancestral form leaves such as those of *D. borneensis* Beec., and *D. collyris* Wall., in which the leaves are convex. He considers that the view of Treub, that the pitchers are water-economizers, corresponds most nearly with the facts, and while it is only in certain cases they collect rain water, under all circumstances they serve to preserve water lost by transpiration. The whole root system of the plant is adventitious and the pitchers are provided with a copious root system derived from one or more of a pair of aerial roots originating from the petiole or the closely adjacent stem. There can be little doubt, he thinks, that the roots utilize the humus contained in the pitchers as if it were ordinary soil, and accepts the suggestion of Groom that the organic matter is brought in by ants. He concludes, then, that there is in this plant a complex adaptation in which the leaves, originally developed for the purpose of storing and economizing water, often imperfectly perform this function and are then taken possession of by ants which supply solid in place of the liquid nutriment.

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[40] PENZIG, O., Note di Teratologia Vegetale. Malpighia **16**: 164–176. *pls. 4–6.* 1902.

IN DIE TROPENPFLANZEN (**6**: 389. 1902) there is given a photograph of a "double" Ananas from the Azores. Harshberger[43] has recently written of the fasciation in the pineapple from Jamaica, where it seems to be not at all uncommon. Usually the form assumed is fan-shaped, the component fruits being arranged side by side, but sometimes one or more project, forming an irregularly disposed row. The smallest example examined consisted of two united fruits, while the largest, twenty inches across and twelve inches high, was composed of a dozen or more.

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[41] Annals of Botany **7**: 243-260. *pls. 11-12.* 1893.

[42] THISTLETON-DYER, W. T., Morphological notes. VII. Evolution of pitchers in *Dischidia rafflesiana*, Annals of Botany **16**: 365-369. *pls. 14-15.* 1902.

[43] HARSHBERGER, J. W., Coxcomb fasciation of pineapples. Proc. Acad. Sci. Philad. **53**: 609-611. 1902.

FASCIATION in the sweet potato is the subject of a paper by Conard,[44] who gives observations on the frequency of occurrence and the form and histology of the formation in its usual type as well as in the interesting condition known as "ring-fasciation." Besides the description of his own material, he refers quite extensively to other forms and to the literature — a virtue in which so many of the teratological papers are sadly deficient.

CARLETON E. PRESTON (Amer. Nat. **36**: 727–734. *figs. 10.* 1902) considers the foliage of Acacia and finds considerable variation in the forms of the pinnate leaves. In the production of the phyllodia he found some forms which, while they may be mere anomalies, might seem to indicate that this organ may not be entirely petiolar in nature, the rachis as well as the petiole being concerned in its formation, and the pinnae dropping from the base or the tip of the central axis.— PENZIG (*loc. cit.*) describes and figures among others an abnormality in the flower of *Gladiolus segetum.* The abnormal example shows a perianth of nine instead of six parts, four instead of three stamens, and a five-parted stigma with an ovary of five carpels instead of the usual number.—COPELAND (BOT. GAZ. **34**: 142–144. *figs. 5.* 1902) describes and figures abnormal forms of *Asplenium pinnatifidum* Nutt. and *Polypodium vulgare* L. found on the Laurel ridge in northern West Virginia, and suggests that, while they are not necessarily any support for the theory of De Vries as to the origin of new species, the value of the study of such freaks as these in connection with the questions De Vries has raised is self-assertive.— EICHLER (Jahreshefte der Ver. vaterl. Naturk. in Württemberg **58**: LXXI–LXXII. 1902) gives some brief notes of a teratological nature and also some suggestions on xenia and double fertilization.—PERROT (Bull. Soc. Bot. France **49**: 163–166. *figs. 6.* 1902) publishes observations on the general form and histological structure of excrescences found on the ventral surface of leaves of *Aristolochia Sipho*, and suggests that the excrescences are the result of an effort to increase the transpiration surface. The formations clearly belong to those occurring in various species of plants which have been designated as "seam-like" outgrowths. No reference is made to the literature. The formation has been described for this species by a half-dozen or more writers.— CAMUS figures and very briefly describes (Bull. Soc. Bot. France **49**: 70–71. *pl. 1.* 1902) monstrosities in *Salix hippophaefolia* Thuill. caused by *Ceidomya rosaria* H. Lev.—PROLIFICATION in the pear, where it has frequently been described, is noted and figured in the *Lyon Horticole* (**24**: 81–85. 1902), and prolification of the fruit of Capsicum, a very common occurrence and one which has been three or four times treated in the literature, is figured in a later number of the same journal (**24**: 382–385. 1902).—J. ARTHUR HARRIS.

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[44] CONARD, H. S., Fasciation in the sweet potato. Contrib. Bot. Lab. Univ. Penn. **2**: 205–215. *pl. 19.* 1902.

JUEL,[45] while traveling in Tunis, secured a specimen of the curious parasite *Cynomorium coccineum*, and succeeded in keeping it alive until he had secured material for the entire life-history except the seed and seedlings, and even this gap was filled later from material collected in Trapani. He had thought that a careful study might reveal some such condition as that described by Treub for Balanophora, but fertilization and the formation of the embryo take place in the usual manner, as had already been shown by Pirotta and Longo. The behavior of the megaspore mother-cell is peculiar. The two cells resulting from the first division of the megaspore mother-cell are very unequal, the one nearest the micropyle being considerably smaller. This smaller cell divides longitudinally and the larger one transversely, thus giving rise to four megaspores, of which the one nearest the chalaza develops at the expense of the other three. The peculiar arrangement of the four megaspores and their inequality in size are habitual, having been noted in twenty cases. Artificial pollination showed that fertilization takes place four days after pollination; sixteen days after pollination embryos of various sizes were found. The antipodals do not divide, as described by Pirotta and Longo, but may be distinguished as three undivided cells even after the endosperm has become abundant. In the ripe seed the embryo is a small spherical mass of cells with no suspensor and no differentiation into body regions.—CHARLES J. CHAMBERLAIN.

[45] JUEL, H. O., Zur Entwickelungsgeschichte des Semens von Cynomorium. Beih. Bot. Centralbl. 13: 194–202. *figs. 5.* 1902.

NEWS.

ED. REINECK has succeeded the late G. Leimbach as editor of the *Deutsche botanische Monatsschrift.*

Dr. P. P. DEHÉRAIN, professor of plant physiology at the Muséum d'Histoire Naturelle at Paris, and editor of the *Annales Agronomiques*, died recently.

ON NOVEMBER 27 a celebration was held in honor of M. Chr. Gobi, professor emeritus of the Imperial University of St. Petersburg, to commemorate the completion of thirty years of activity in teaching and investigation.

THE OFFICERS of the Botanical Society of Washington for 1903 are A. F. WOODS, president; FREDERICK V. COVILLE, vice-president; CHARLES L. POLLARD, recording secretary; HERBERT J. WEBBER, corresponding secretary; and WALTER H. EVANS, treasurer.

PROFESSOR L. CELAKOVSKY, professor of botany and director of the botanical institute and gardens of the University of Prag, died November 24 last, at the age of sixty-seven years. His numerous botanical contributions are well known, and his death has removed one of the most constant contributors to botanical literature.

E. P. BURTON & CO., a lumber firm of Charleston, S. C., have asked for the help of the Bureau of Forestry in managing 60,000 acres of pine forest about thirty miles northwest of Charleston, on the Cooper River. The forest consists mainly of loblolly, with some longleaf and spruce pine. It contains also some large swamps with heavy stands of cypress, gum, and oaks.

THE UNIVERSITY OF MICHIGAN has secured the lease of a piece of ground containing about seven acres for a botanical garden and arboretum. The land is located in immediate proximity to the campus and adjacent to other university property. It includes a "kettle hole," which will be utilized for the growth of aquatics, and has the advantage of great variety of slope, soil, and exposure. The front nearest to the university buildings is reserved for the erection of a conservatory with workrooms.

DR. A. WAGNER, of the University of Innsbruck, has announced the publication of a new periodical to be entitled "Botanisches Litteraturblatt." It is to be an "organ for author reports of the whole domain of botany." The "autoreports" of foreign authors, if not written in German, will be published in "literal German translation." The publisher is Wagner, bookseller to the University of Innsbruck. In case an author declines to furnish a report of his paper, "eventual reports will be reserved to the editor." The subscription "for the first annual course" (twenty-four numbers) is *Kro.* 28.

THE FIRST NUMBER of *The Forestry Quarterly* has made its appearance, bearing the date October, 1902. It is published under the direction of the New York State College of Forestry at Ithaca, and has for its objects to aid in the establishment of rational forest management, to be an organ for the publication of technical papers on forestry, and to keep those interested in forestry in touch with the current technical literature and the forestry movement in the United States. The *Forestry Quarterly* is the only publication in this country devoted entirely to the interests of the science of forestry. A valuable feature is its review of current literature. The annual subscription price is one dollar.

THE BUREAU OF FORESTRY has shown the damage caused by forest fires in northwestern Oregon and southeastern Washington during September, and a conservative estimate places the damage at $12,767,100. Of this amount $8,857,100 is in Washington. The estimate includes losses to farm property, saw mills, manufactured lumber, standing timber, etc., and is based on personal observation, conferences with lumber men, farmers, settlers, and other trustworthy sources of information. Much of the area burned over was covered with virgin forest, mainly of Douglas spruce, cedar, and hemlock. Since most of the fires could have been extinguished before they became serious, it is evident that an efficient system of forest patrol would have prevented most of this loss.

THE OFFICE of experiment stations, U. S. Department of Agriculture, has published (Exp. Sta. Record **14**: No. 3) an account, prepared by DR. WALTER H. EVANS, of the International Conference on plant-breeding and hybridization held in New York city September 30 to October 2, 1902, under the auspices of the Horticultural Society of New York. A program of over fifty papers was presented, and all of them are to be published in full in Proc. N. Y. Hort. Soc. The account referred to above gives synopses of certain papers, among which are the following: Practical aspects of the new discoveries in heredity, W. BATESON; Notes on Mendel's methods of plant-breeding, C. C. HURST; Artificial ataviem, HUGO DE VRIES; Some suggestions for plant-breeding, MAX LEICHTLIN; Some suggestions for the classification of hybrids, I. T. LYNCH; Principles of plant-breeding, LUTHER BURBANK; Breeding of disease-resistant varieties, W. A. ORTON; Breeding for intrinsic qualities, W. M. HAYS; Correlation between different parts of the plant in form, color, and other characteristics, S. A. BEACH; The varying tendency and individual prepotency in garden vegetables, W. W. TRACY; Cross-fertilization of the sugar cane, D. MORRIS; Cytological aspects of hybrids, W. A. CANNON; A medley of pumpkins, L. H. BAILEY.

DR. TIMOTHY FIELD ALLEN died at his home in New York city December 5, 1902. He was born in Westminster, Vt., April 24, 1837, and was therefore in his sixty-sixth year. Dr. Allen was one of the organizers of the Torrey Botanical Club, and until the last two or three years, when failing health compelled a partial retirement, was one of the leading spirits in its work. He was early interested in the local flora of the New York city region and assisted in the publication of local lists of the higher plants. His attention, however, was soon drawn to the Charales, and he was for many years the best known American student of this taxonomically difficult group of plants. His extensive collections of Charales, especially rich in North American and Japanese forms, together with his books relating to this order of plants, including the duplicate stock of his own publications, were given to the New York Botanical Garden early in 1901. Dr. Allen was for a long time professor of materia medica and dean of the New York Homoeopathic Medical College, and later president of its board of trustees. He was also president of the New York Ophthalmic Hospital. He was the author of a large work on materia medica and of numerous papers on ophthalmology, etc. In 1885 the degree of LL.D. was conferred upon him by Amherst College, from which he was graduated in 1858.

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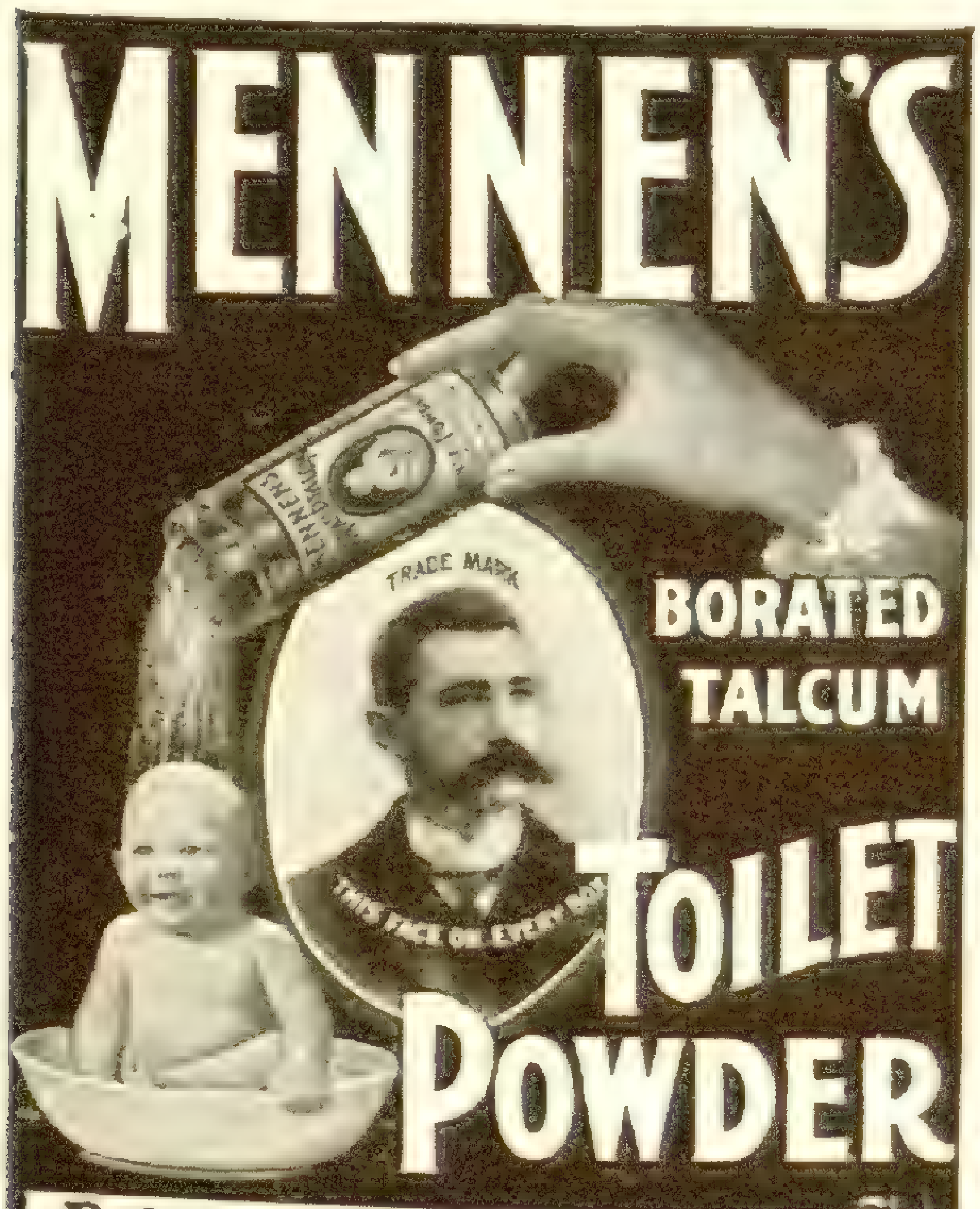

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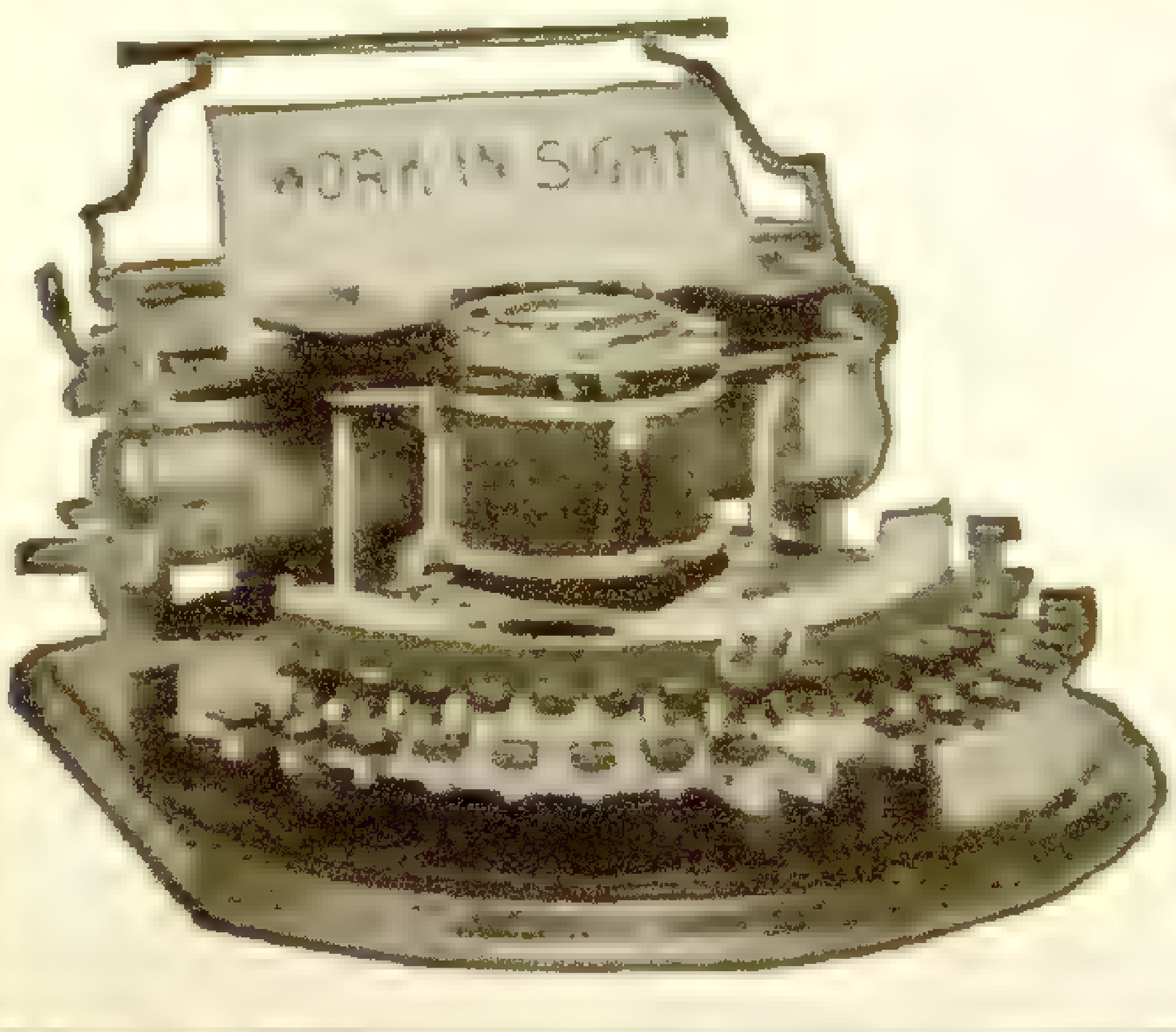

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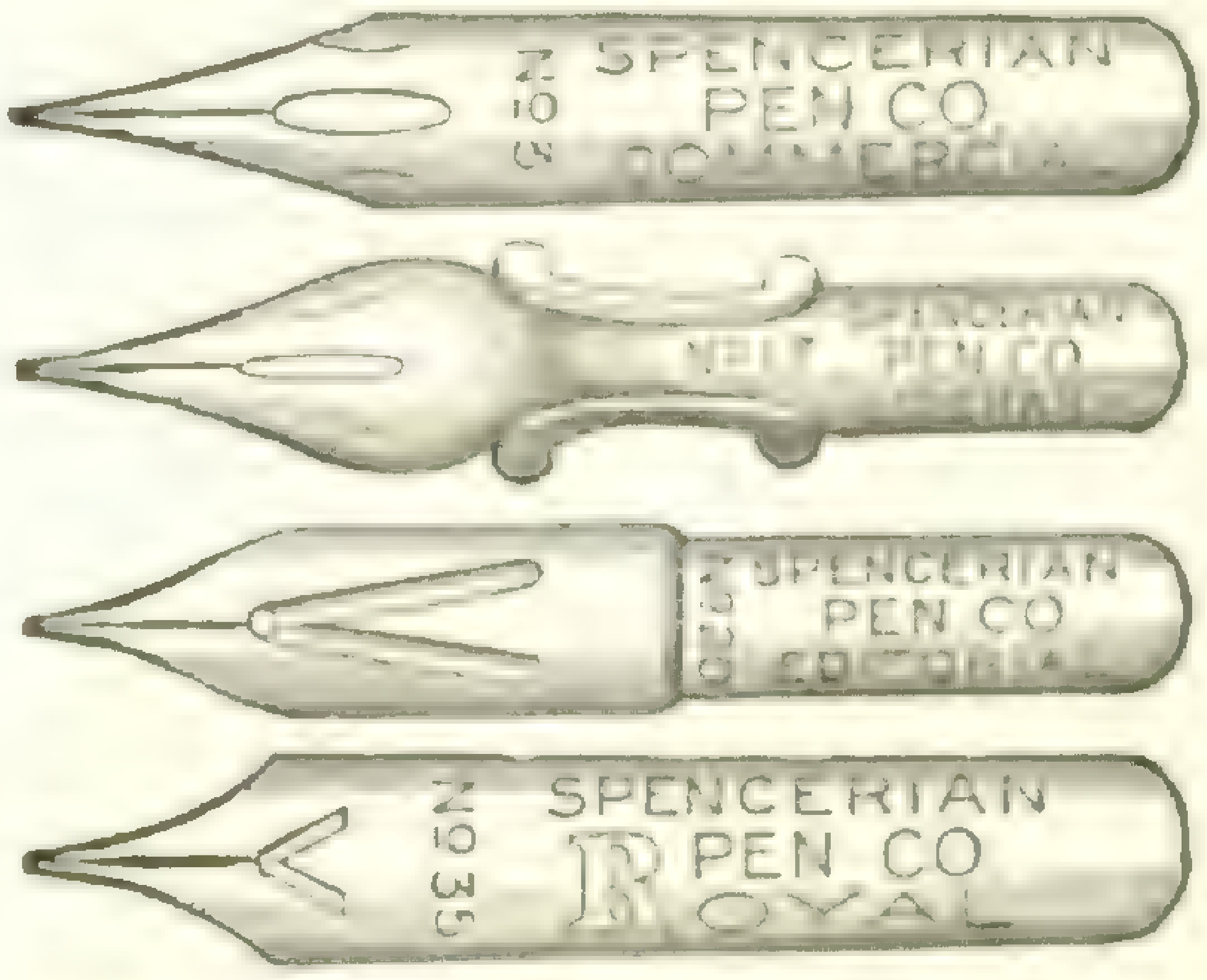
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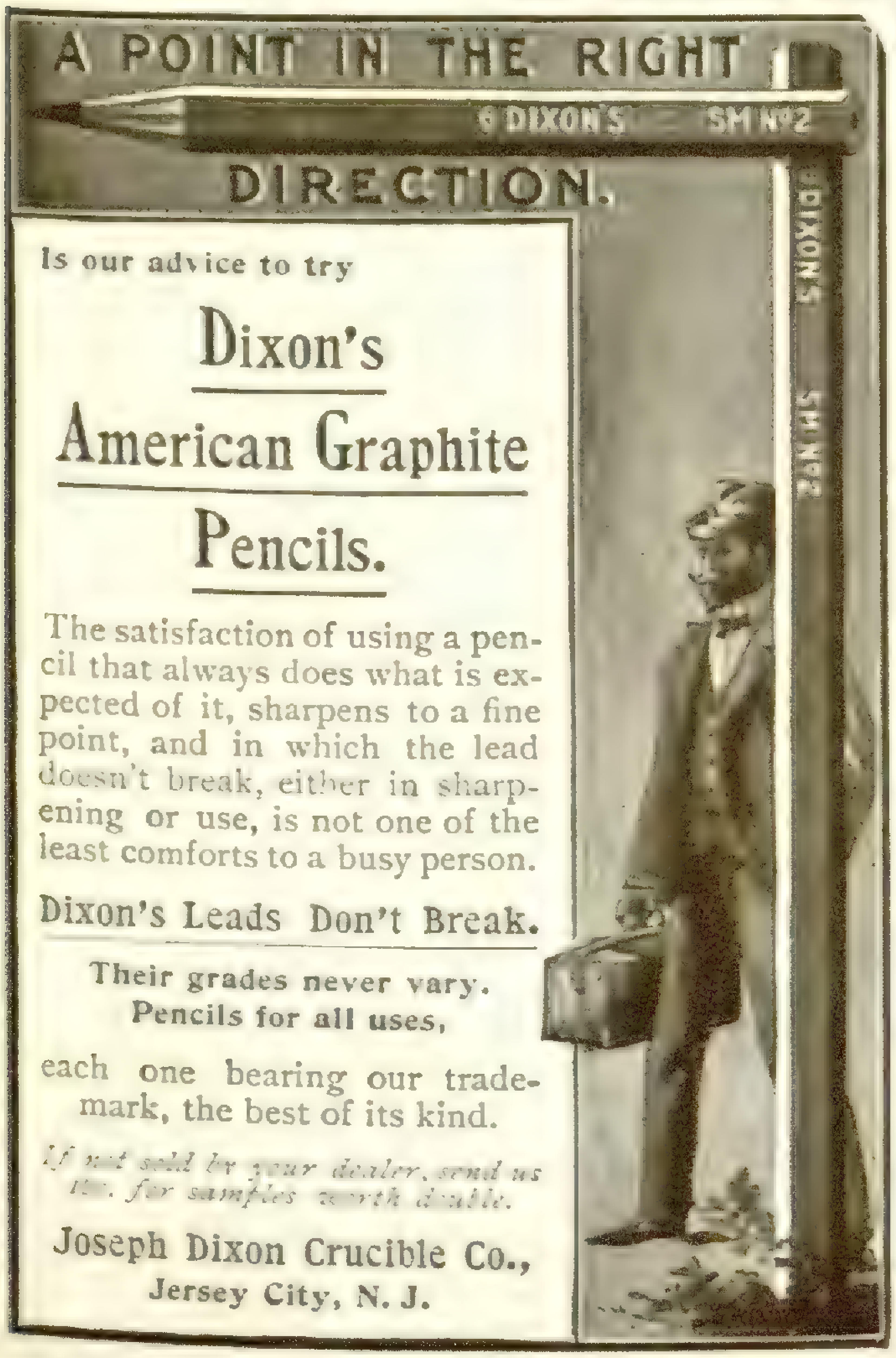
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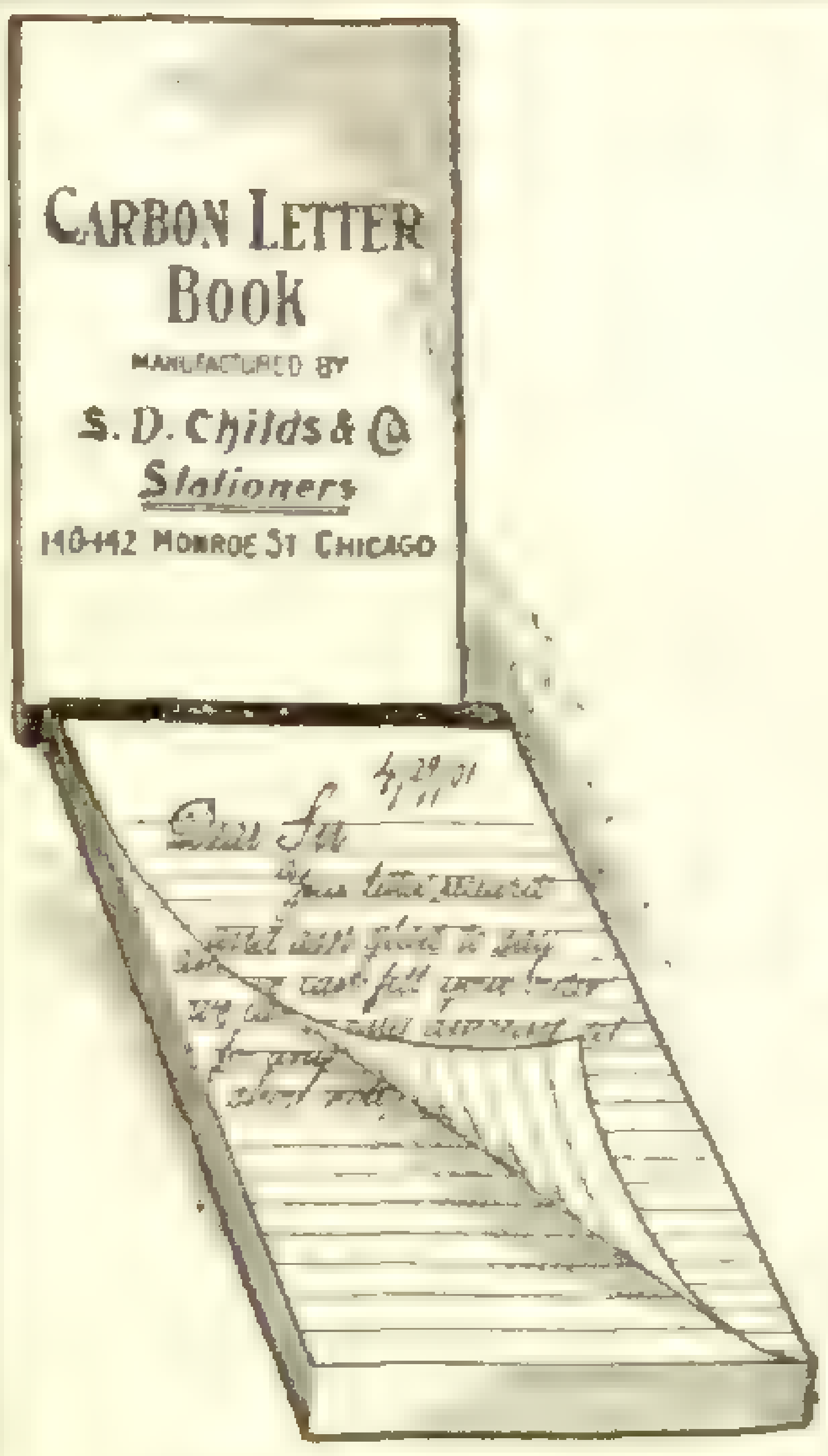

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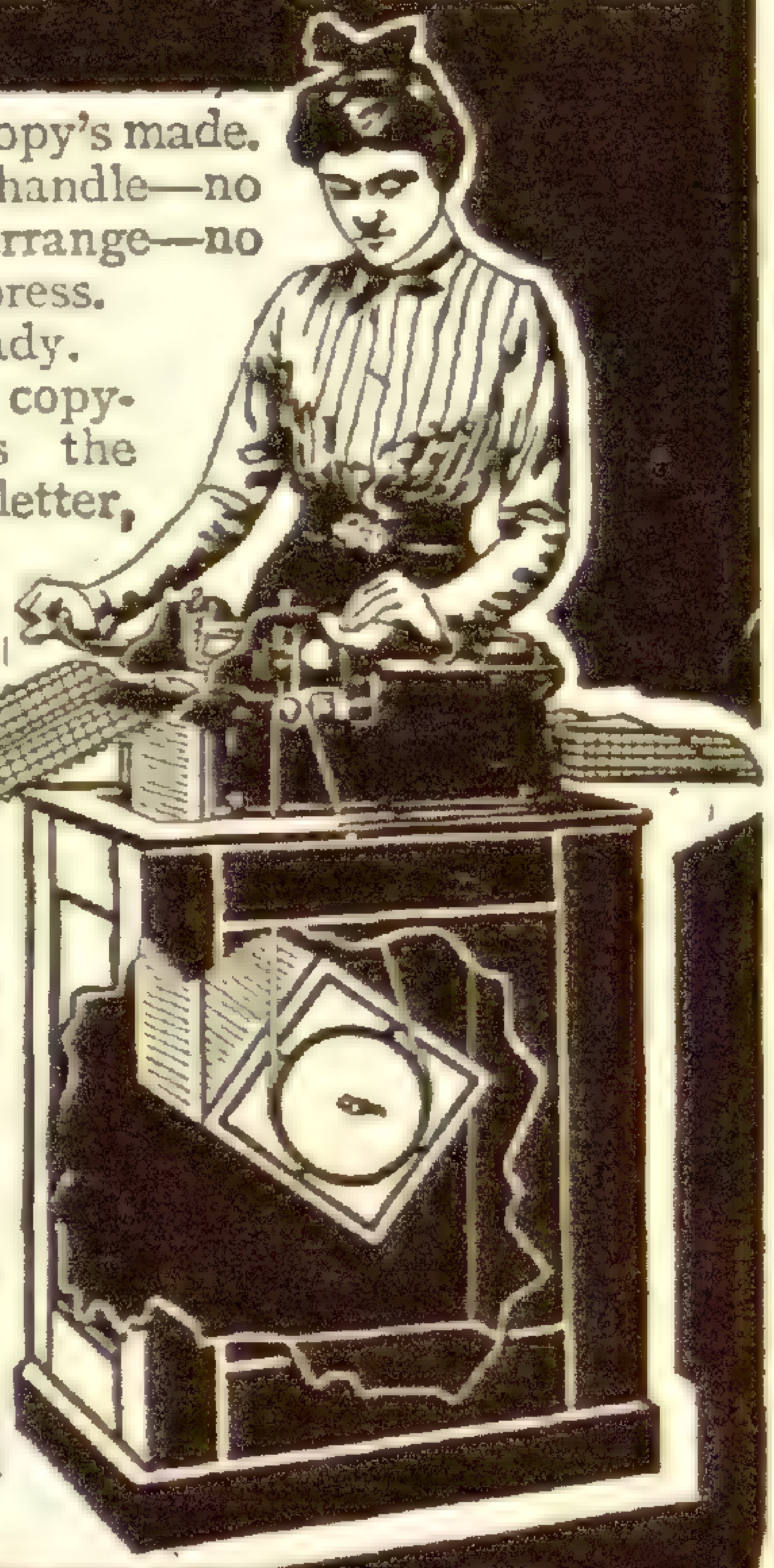

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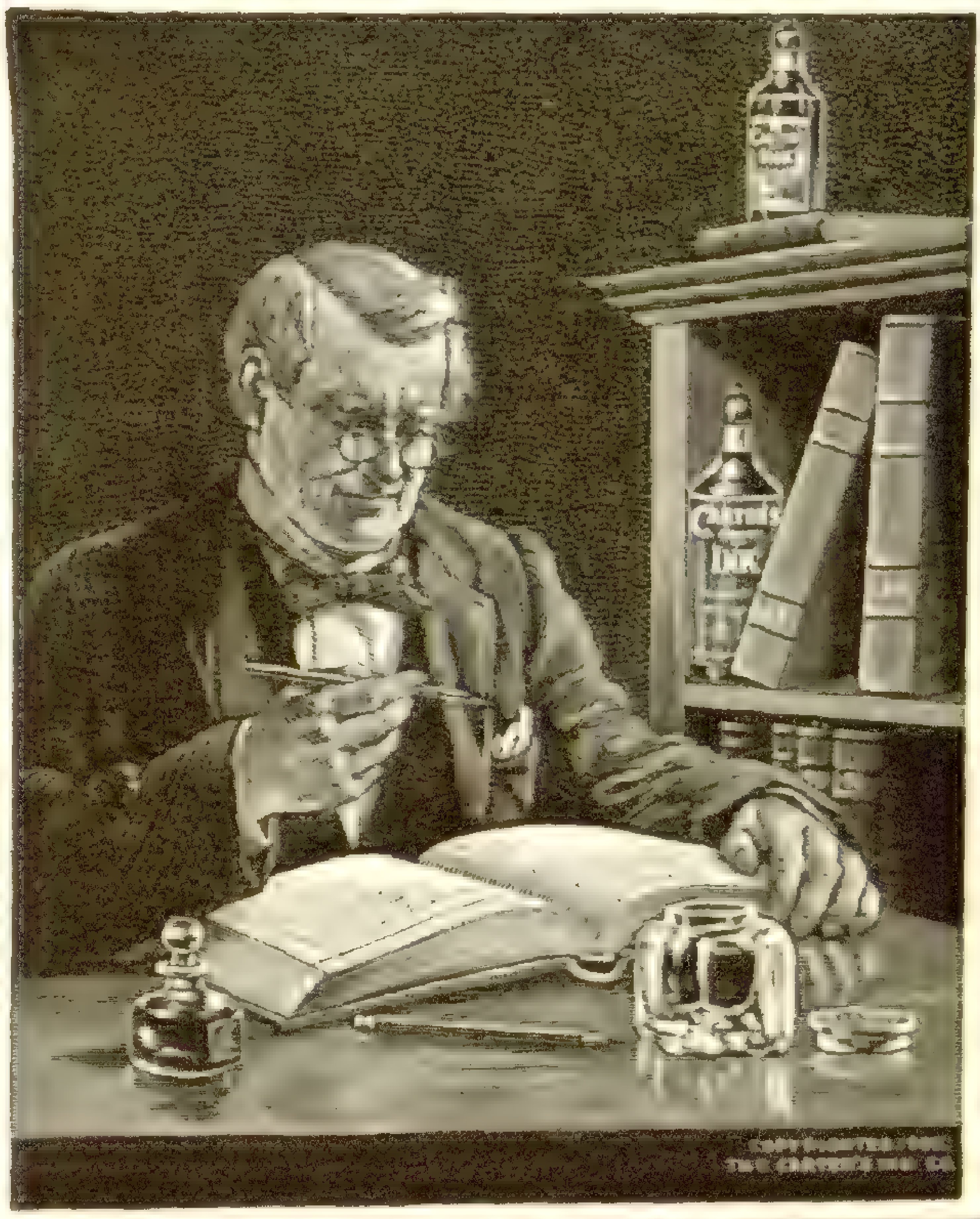

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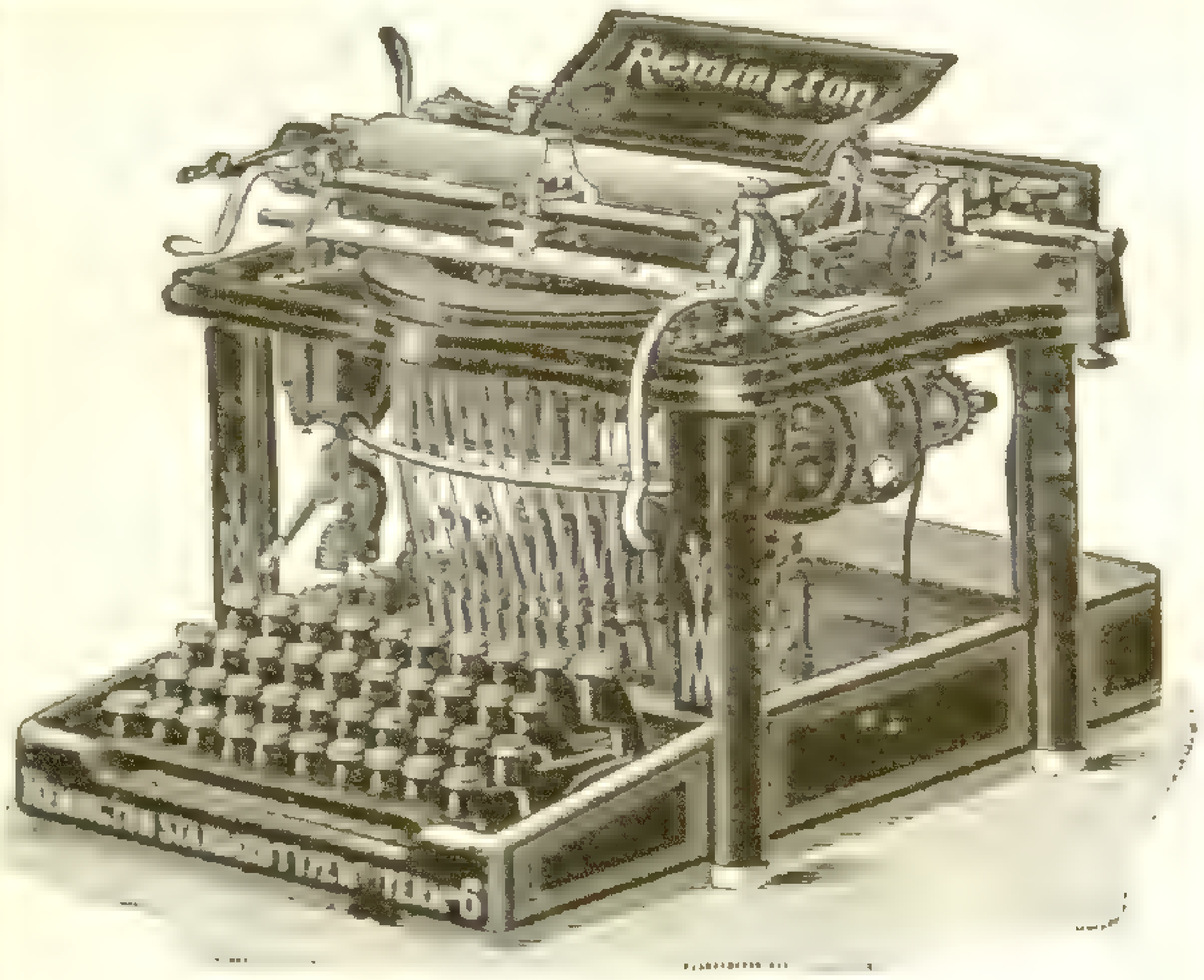

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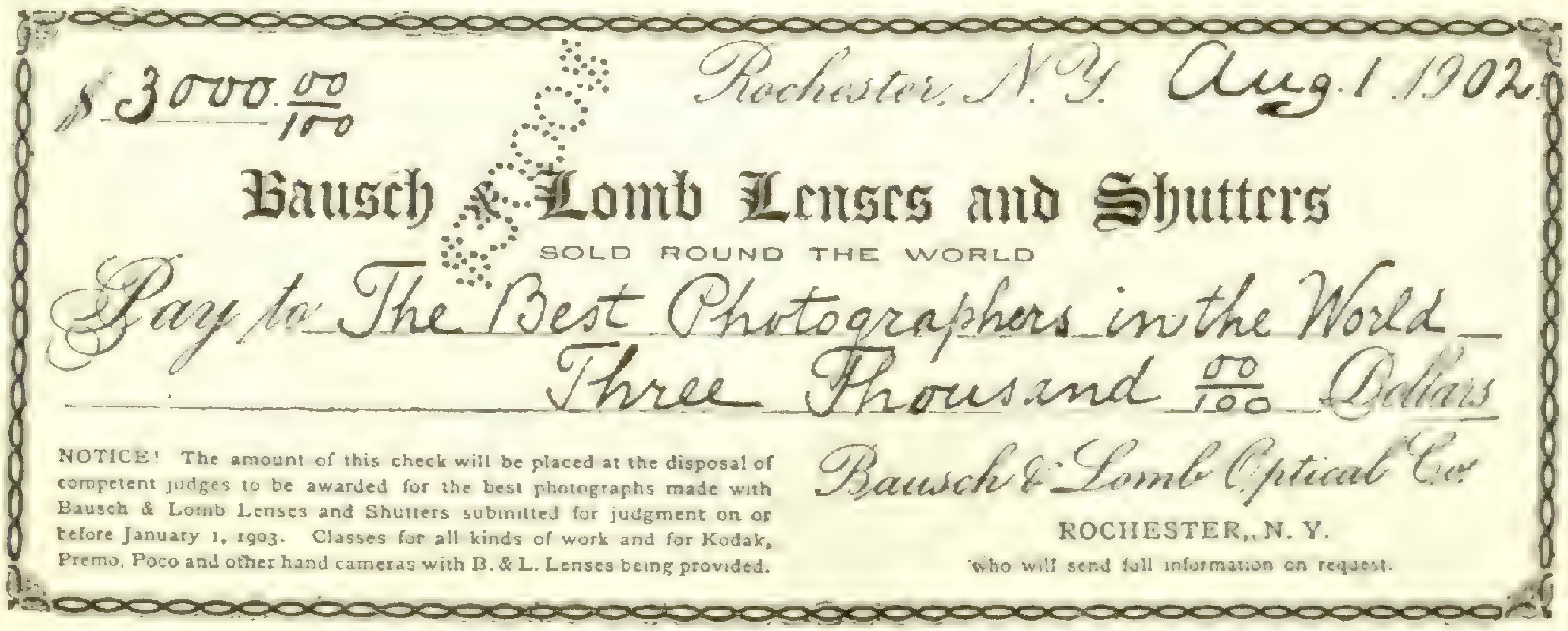

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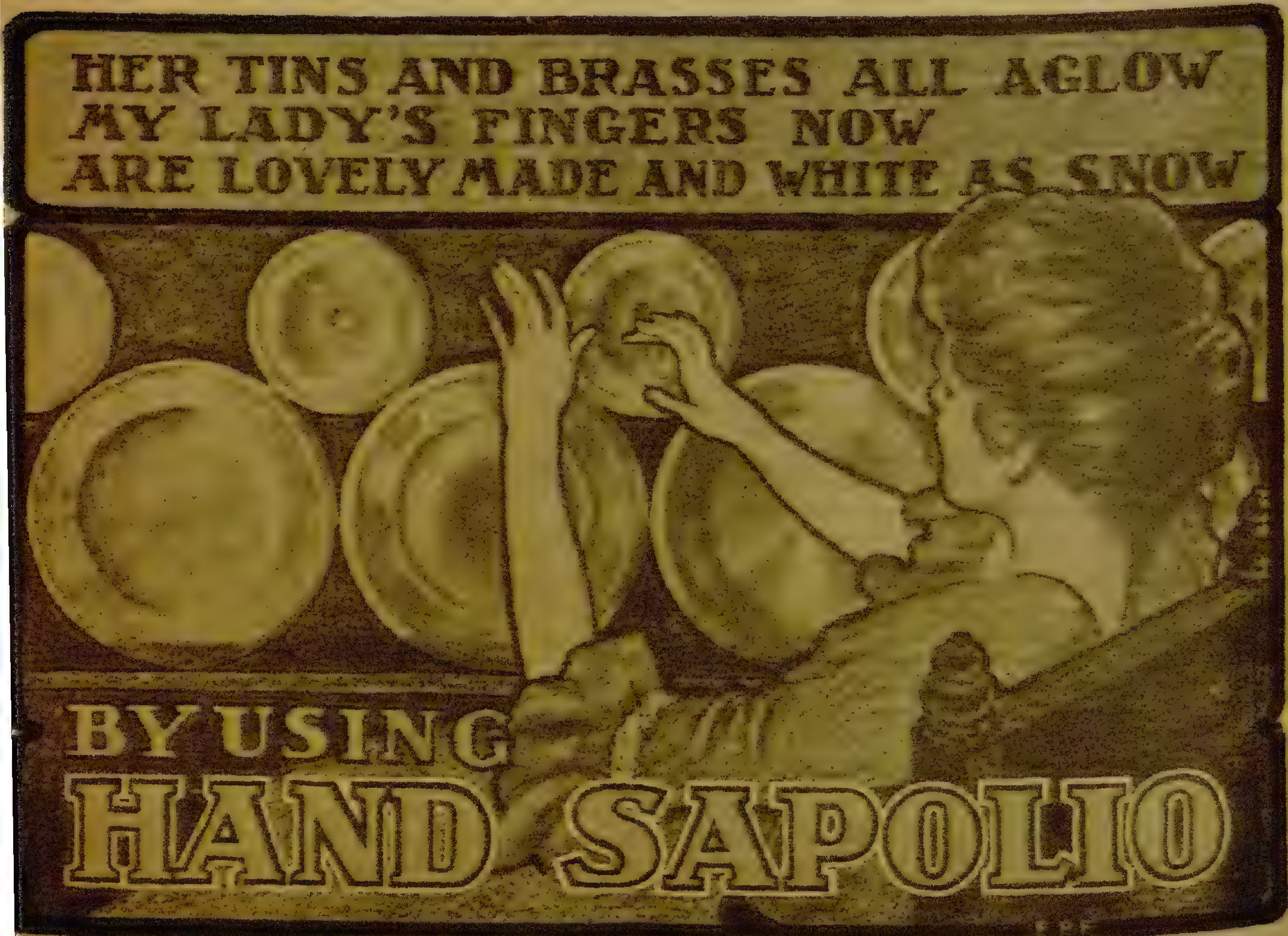
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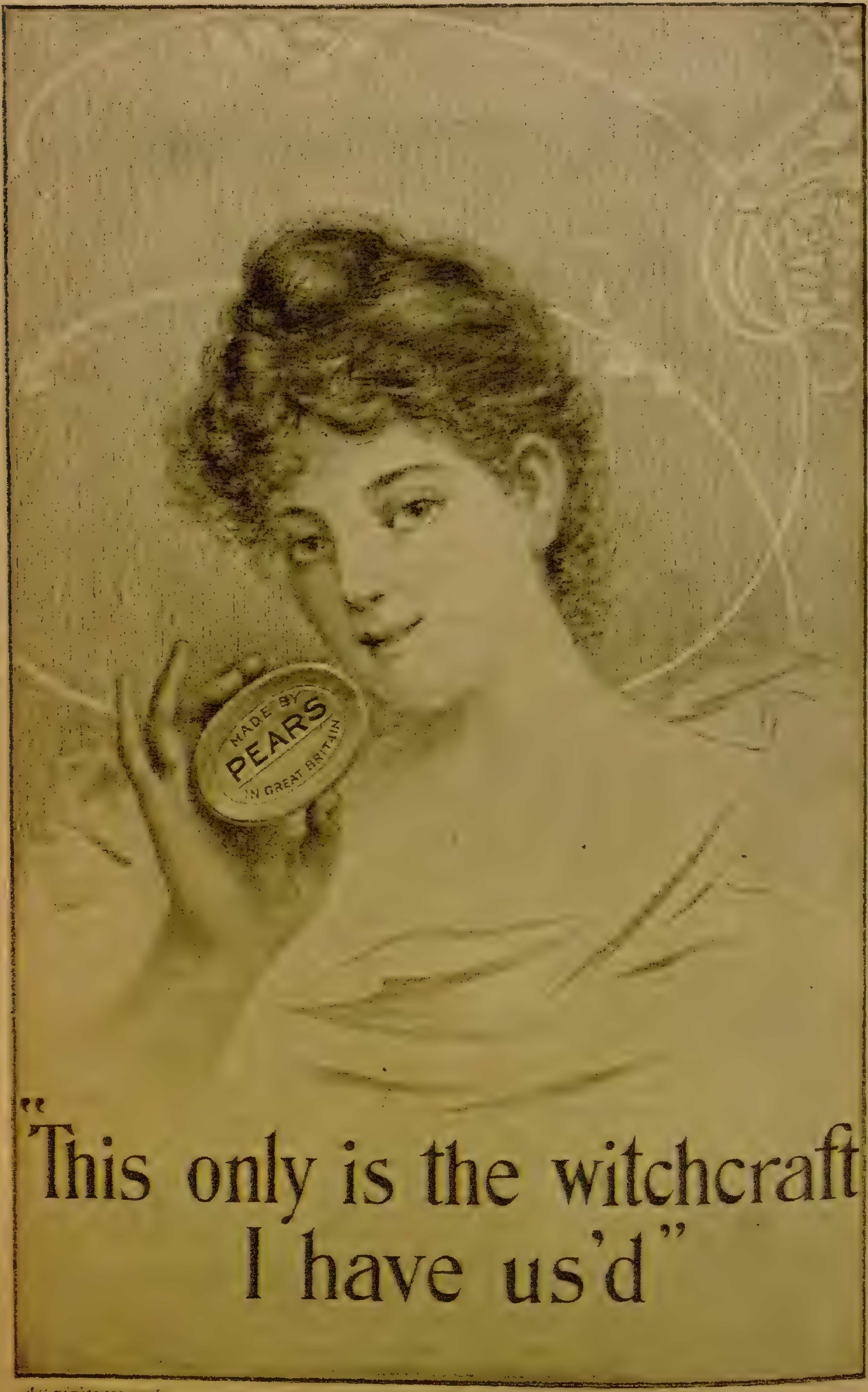
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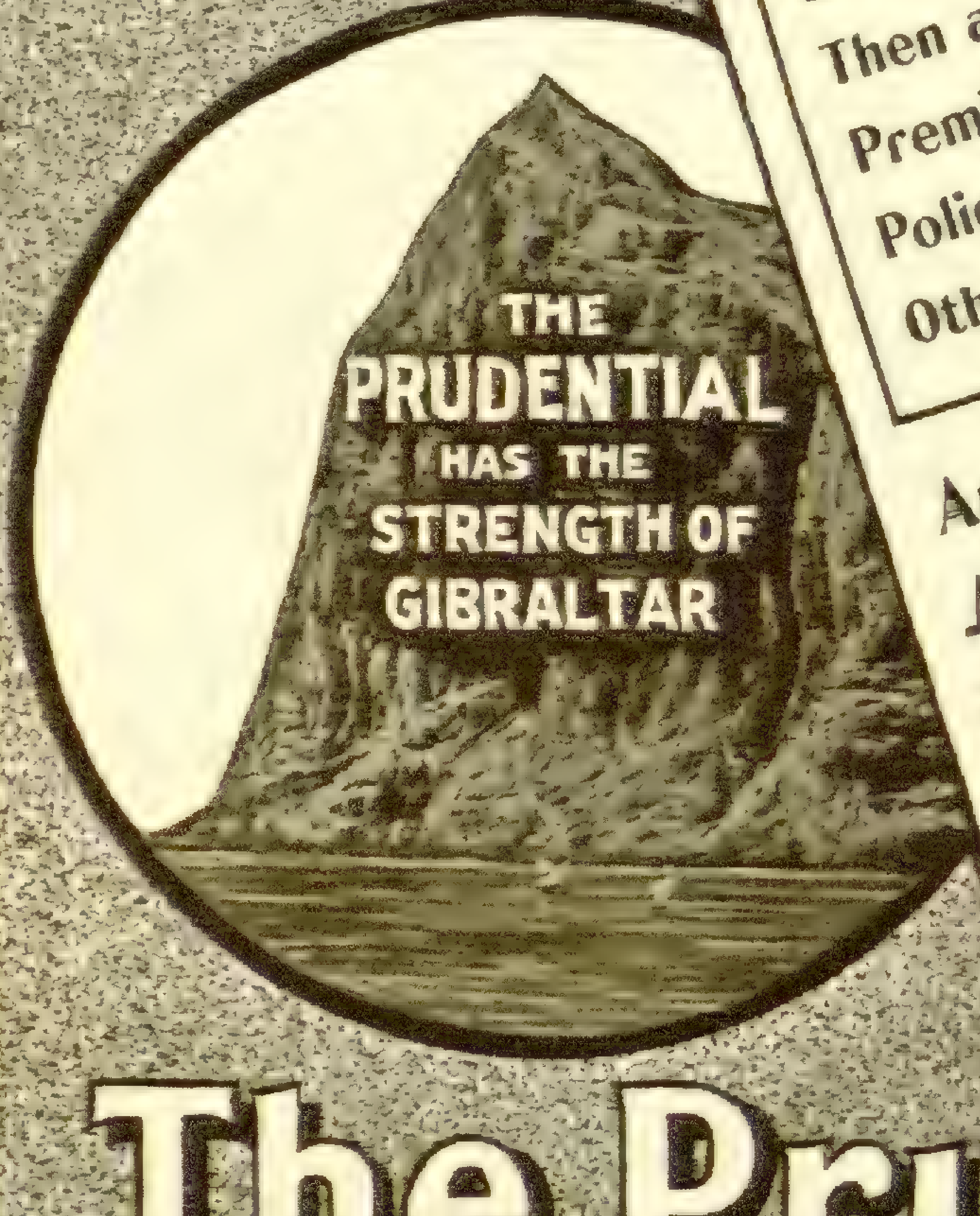

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BOTANICAL GAZETTE

FEBRUARY, 1903

CHEMICAL STIMULATION AND THE EVOLUTION OF CARBON DIOXID.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XLIV.

EDWIN BINGHAM COPELAND.

(WITH TWO FIGURES)

SEVERAL years ago, in a study by Kahlenberg and myself[1] of the effect of placing small pieces of various chemical elements in water where seedlings were growing, it was found that in a considerable number of instances the roots of the seedlings exhibited an acceleration of growth, which we construed as an effect of the chemical employed. In individual cases we found a rapid elongation of the primary root, probably resulting from the action of Bi, Cr, In, Se, Te, Hg, Bo, Pb, W, Co, and Cu. This abnormally rapid growth was frequently followed promptly by death. As the compounds of these elements began to enter into solution, their first action on the plant was that of stimulants; when these same compounds became more concentrated, they became distinctly, often fatally, toxic.

The stimulating action of minute quantities of various poisons has long been known in the case of a few fungi. Raulin[2] found that salts of Zn, Fe, and Mn, as well as silicates, caused an unusually luxuriant growth of Aspergillus. Richards[3] extended

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[1] COPELAND, E. B., and KAHLENBERG, LOUIS, The influence of the presence of pure metals upon plants. Trans. Wisc. Academy **12**:454–474. 1899.

[2] RAULIN, J., Études chimiques sur la végétation. Ann. Sc. Nat. Bot. V. **11**:93–299. 1869.

[3] RICHARDS, H. M., Die Beeinflussung des Wachsthums einiger Pilze durch chemische Reize. Jahrb. Wiss. Bot. **30**:665–688. 1897.

Raulin's observations, using Aspergillus, Penicillium, and Botrytis as subjects, and Zn-, Fe-, Co-, and Ni-sulfates, NaFl, LiCl, Na_2SiO_3, cocain, morphin, and amygdalin as stimulants. He also recognized the phenomenon in its true light, as one of stimulation. Ono[4] used almost exclusively the same salts and $HgCl_2$ in addition, with the same results as Richards. Richter,[5] from work with a wide range of concentrations, regards the Zn ion as stimulating the growth of Aspergillus, but the ZnSO molecule as depressing it, and recognizes no acceleration under the influence of Cu. Pulst[6] added Mucor to the list of subjects, and Cd and Tl to the list of poisons which stimulate growth if sufficiently dilute. Hattori[7] has also found abnormally active growth of fungi in $CuSO_4$ solutions, De Seynes[8] describes a strain of Penicillium thriving in it, and Gosio[9] reports Mucor, Aspergillus, and another strain of Penicillium thriving in the presence of arsenic. Similar observations to Gosio's were made long ago by Preuss[10] and Bouchardat.[11] Yasuda[12] finds that the addition of suitable amounts of alkaloids to the nutrient solutions favors the growth of molds, the mode of action, whether as food or stimulant, not being determined.

Turning to plants other than the fungi, a similar stimulating action of dilute poisons, well established in those organisms physiologically nearest them, the bacteria, led Hueppe[13] to the formulation of this "biologischen Grundgesetz:"

---

[4] Ono, N., Notes on the stimulating effect of certain substances upon the growth of algae and fungi. Bot. Mag. Tōkiō **14**:75–78. 1900. Also, Ueber die Wachsthumsbeschleunigung einiger Algen und Pilze durch chemische Reize. Jour. Coll. Sc. Imp. Univ. Tōkiō **13**:141–186. 1900.

[5] Richter, A., Zur Frage der chemischen Reizmittel. Centralbl. Bakteriol. **7**:417–429. 1901.

[6] Pulst, C., Die Widerstandsfähigkeit einiger Schimmelpilze gegen Metallgifte. Jahrb. Wiss. Bot. **37**:205–263. 1902.

[7] Hattori, Studien über die Einwirkung des Kupfersulfats auf einige Pflanzen. Jour. Coll. Sc. Imp. Univ. Tōkiō **15**:371–394. 1901.

[8] De Seynes, J., Resultats de la culture du *Penicillium cupricum* Trabut. Bull. Soc. Bot. France **42**:451–455, 482–485. 1895. [Bot. Centralbl. **66**:157.]

[9] Gosio, B., Zur Frage, wodurch die Giftigkeit arsenhaltiger Tapeten bedingt wird. Ber. Deutsch. Chem. Ges. **30**:1024–1026. 1897.

[10] Preuss, Wirkung des Arseniks auf Vegetabilien. Bot. Zeit. **6**:409–412. 1848.

[11] Bouchardat, Recherches sur la végétation appliquées à l'agriculture. Paris, 1846. Rev. in Bot. Zeit. **5**:85, 102. 1847.

[12] Yasuda, A., On the effect of alkaloids upon some moulds. Bot. Mag. Tōkiō **15**:79–83. 1901.

> Jeder Körper, der in bestimmter Concentration Protoplasma tödtet und vernichtet, in geringeren Mengen die Entwickelungsfähigkeit aufhebt, aber in noch geringeren Mengen, jenseits eines Indifferenzpunktes, umgekehrt als Reiz wirkt und die Lebenseigenschaften erhöht.

Ono (*l. c.*) detected an acceleration of the growth of algae by all the same substances to which his fungi responded, except Hg; but found the optimum concentration much lower, corresponding to the greater susceptibility of the alga to injury by these poisons.

Our information on the chemical stimulation of the growth of phanerogams is altogether fragmentary. The most familiar example of this is the exceptionally luxuriant growth of violets and some other plants in the neighborhood of zinc works. Rumm[14] finds that in grape vines sprayed with copper various leaf tissues become better developed, and the fruit ripens earlier. Berlese and Sostegni[15] substantiate this, but seem to believe that the most important immediate effect of the copper is the increase of the cyanophyll, other effects being results of this. Frank and Krüger[16] show that potatoes sprinkled with copper solutions excel in leaf area, length of life, and amount of crop. Townsend finds that the growth of Avena seedlings is accelerated at least temporarily by not too much ether in the atmosphere;[17] that the germination of various seeds and spores may be hastened by weak enough ether,[18] and that germination and subsequent growth can be accelerated by a short exposure to HCN gas.[19] Lövinson[20] discovered that germination was hastened by CS_2. De Toni and Mach[21] are said to get the same result by treating tobacco seeds with alkaloids; Windisch[22] finds that $Ca(OH)_2$, though damaging to some kinds of seeds, improves the germination of oats; and Böttger[23] has hastened the germination of coffee with dilute KOH. Kahlenberg and True[24] found that in acid solutions their seedlings had a tendency toward abnormally rapid growth, followed by death; but experiments on this point with HCl yielded only negative results. An unsigned note[25] in an old Flora says:

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[13] HUEPPE, F., Naturwissenschaftliche Einführung in die Bakteriologie. Wiesbaden. 1896. Hueppe gives Arndt and Schultz joint credit with himself for this generalization.

[14] RUMM, C., Ueber die Wirkung der Kupferpräparate bei Bekämpfung der sogenannten Blattkrankheit der Weinrebe. Ber. Deutsch. Bot. Gesells. **11**: 79–93. 1893.

[15] BERLESE et SOSTEGNI, Recherches sur l'action des sels de cuivre sur la végétation de la vigne et sur le sol. Rev. internat. de Vitic. et Oenologie. 1895. [Bot. Jahresber. **23**^{1}: 292–294. 1895.]

[16] FRANK, B., und KRÜGER, F., Ueber den Reiz welchen die Behandlung mit Kupfer auf die Kartoffel hervorruft. Ber. Deutsch. Bot. Gesells. **12**: 8. 1894.

[17] TOWNSEND, C. O., The correlation of growth under the influence of injuries. Ann. Botany **11**: 509–532. 1897.

> Bekanntlich können Samen, welche schwer keimen, oder die Fähigkeit dazu bereits verloren haben, dadurch zum Keimen gebracht werden, dass man dieselben längere Zeit in mit Salzsäure schwach angesäuertes Wasser legt.

This is followed by a review of work, the original publication of which in "Silliman's Journal" I have not located, on seeds treated with very dilute HCl. *Lactuca sativa* in these experiments was two and one-half inches high in 48 hours, and in eight days had reached the state of development normally requiring five or six weeks; and young pines and firs grew so, that, at the end of three months, they were taken for two years old.

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[18] TOWNSEND, C. O., The effect of ether upon the germination of seeds and spores. BOT. GAZ. **27**: 458–466. 1899.

[19] TOWNSEND, C. O., The effect of hydrocyanic acid gas upon grains and other seeds. BOT. GAZ. **31**: 241–264. 1901.

[20] LÖVINSON, O., Ueber Keimungs- und Wachsthumsversuche an Erbsen in Lösungen von fettsauren Salzen unter Ausschluss von Mineralsäuren. Bot. Centralbl. **83**: 1, 33, 65, 97, 129, 185, 210. 1900.

[21] DETONI, B. G., e MACH, P., Sopra l'influenza esercitata della nicotina, etc. Boll. R. Ist. Bot. Univ. Parmiense. 1893. Not seen.

[22] WINDISCH, R., Ueber die Einwirkung des Kalkhydrates auf die Keimung. Landw. Versuchsst. **54**: 283–309. [Bot. Centralbl. **87**: 217.]

[23] BÖTTGER, R., Beförderung des Keimprocesses. Jahresb. phys. Ver. Frankfurt. 1872-3. [Bot. Jahresber. **1**: 833. 1874.]

[24] KAHLENBERG, L., and TRUE, R. H., On the toxic action of dissolved salts and their electrolytic dissociation. BOT. GAZ. **22**: 81-124. 1896.

[25] Beförderung des Wachsthums der Pflanzen durch Salzsäure. Flora **28**: 464. 1845.

Immediately following the before-mentioned work by Kahlenberg and myself in the spring of 1899, I started a series of water cultures in which Zn and Cu were present. The results were such as to encourage a continuance of the work, and showed that the acceleration of growth is most decided by solutions not a great deal more dilute than those that are distinctly toxic. In fact, the concentrations producing the two effects differed by less than the individual variations of the seedlings used, so that, as in our earlier work when the metals themselves were placed in the water, it sometimes happened that in the same culture (vessel) some plants were evidently injured, while others grew exceptionally well. It is evidently reasonable, even if out of accord with our usual way of looking at it, to regard the acceleration of growth as itself an injury to the plant.

In the summer of 1899 appeared Jacobi's[26] work on the influence of various substances on the respiration and assimilation of water plants. I was immediately impressed with the superiority of respiration to growth as a true index of the plant's activity. I need not enter into a discussion of the relation of respiration to the plant's multifarious other manifestations of activity. It makes available the energy for most of them; without it all would cease. Growth is dependent on respiration, and under ordinary conditions they vary together; when they do not, it is respiration which reveals the plant's real activity. From the minimum to the optimum temperatures for growth, its curve rises with that of respiration, the more rapid combustion in the plant furnishing more energy and proper material for growth. But the more active the respiration, the less the *relative* amount of plastic material left available for growth. A point must be reached, then, beyond which an increase in respiration can reasonably be regarded as itself the cause of a decrease in growth. This is what happens at temperatures above the optimum for growth. How far this loss of material can go during the most rapid respiration is shown by Kraus's[27] classic work, in which he found as much as three-fourths of the substance of some spadices consumed within a few hours; yet respiration need not use up the combustible material at any rate comparable to this to make constructive growth impossible.

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[26] JACOBI, B., Ueber den Einfluss verschiedener Substanzen auf die Athmung und Assimilation submerser Pflanzen. Flora **86**: 289–327. 1899.

[27] KRAUS, G., Ueber die Blüthenwärme bei *Arum italicum*. Abhandl. Naturf. Gesells. Halle **16**:—. 1884. Also, Ueber Blüthenwärme bei Cycadeen, Palmen und Araceen. Ann. Jard. Bot. Buitenzorg **13**: 217–275. 1896.

Exactly the same phenomenon should be anticipated when respiration is accelerated by a chemical stimulus as when heat is the agent. The result of moderate stimulation will be a quickening of the growth, but with a more violent stimulation of the respiration, growth will be hindered and ultimately stopped. Wherever my work has thrown any light on this question, it has made this view seem more certainly the correct one. The more concentrated the solutions used, the more is the respiration accelerated, even when the concentration is fatal in twenty-four hours or less. In the isolated case in my experiments, in which with increasing concentration there was an initial decrease in the respiration, the solution was so strong as to plasmolyse the cells violently, and the result was without doubt due to the osmotic (physical) action. In the relatively few instances in which it has been sought, an optimum concentration for vegetative growth has always been determined, and the known antagonistic effect of considerably greater concentrations than those accelerating growth shows that an optimum must exist for each stimulant and plant. An optimum concentration of a chemical stimulant for respiration is not known in a single instance; it does not exist.

The "biologische Grundgesetz" of Hueppe is not fundamental. It applies only to growth, or to growth and other phenomena standing in the same relation with it to respiration. It means merely that when respiration is not already too active, accelerating it will result in a quicker growth. It is indifferent whether the accelerating agent be chemical or thermal. The explanation I have offered of the opposite effects on growth of dilute and more concentrated solutions would do away entirely with Richter's idea that the difference is because ions stimulate, but molecules poison. As already stated, no difference exists except in degree between solutions of different strength in their action on respiration. Richter's explanation is difficult to harmonize with the details of the degrees of dissociation, since dissociation is very nearly complete in fatal concentrations of several poisons (Kahlenberg and True, 1896). And it fails utterly to explain the rather abrupt change from accelerating to obviously toxic concentrations. This quick change has, from my point of view, a perfect analogue in the plant's thermal relations in the steep fall of the curve of growth above the optimum temperature. Even the ion theory can be overworked.

If we interpret the action of chemical stimuli on growth as secondary to that on respiration, we are already armed with an explanation of their influence on reproduction. Klebs[28] has shown that the demands of reproduction upon various conditions are more strict than those of growth. This may be regarded as meaning, in part at least, that the balance of available plastic matter must be relatively great, while the sacrifice of matter for energy must be less than is tolerable for growth. The optimum temperature for reproduction would then be sought below that for growth, and a chemical stimulus accelerating growth might inhibit reproduction. From Klebs[29] again, we know that while the optimum for growth of *Vaucheria repens* is 30° C., the maximum for the formation of zoospores (p. 46) and for sexual reproduction (p. 112) is about 26° C. This idea might still be sound, even if it should be shown that the least perceptible quantity of a poison interfered with reproduction. Of course I offer this only as a suggestion, and do not overlook the very likely alternative that acceleration of the growth is the factor which in its turn injures the reproduction. Of course, too, there are outside factors which act on the growth quite independently of the respiration. The blue end of the solar spectrum slackens growth, but has no well authenticated direct effect on respiration. In the case of all chemical stimuli, however, so far as they are known at all, I hold it more than probable that their apparent effect on growth is a function of their more direct influence on respiration.

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[28] KLEBS, G., Einige Ergebnisse der Fortpflanzungs-Physiologie. Ber. Deutsch. Bot. Gesells. **18**: (201)–(215). 1900.

[29] KLEBS, G., Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen. Jena. 1896.

I have intercalated this discussion at this point, in advance of the evidence on which my opinions are partly based, in order that the primary position of respiration in the plant's economy, and its eminent fitness as a field of study in chemical irritability might be clearly in mind. The importance of respiration will not be at all impaired if the view well maintained in animal physiology by Loeb and others, which regards the energy relations characteristic of living things as electrical rather than thermal, is found altogether correct.

While there is an extensive literature on the influence on respiration of sugars and other substances which furnish the plant with material to be oxidized, there has been surprisingly little work done with chemicals acting primarily as stimulants. The most considerable collection of such data is that of Jacobi, who tested the effect of KNO_3, KCl, NaCl, chinin, antipyrin, I, oxalic acid, and $CuSO_4$ on the respiration of Elodea and Myriophyllum. Some of these substances were given but a single test, and none of them were tried in any considerable range of concentrations. Previous to Jacobi, Kellner[30] had found an acceleration in the respiration of pea seedlings by treating them with KNO_3, and attributed it to direct oxidation by the O of the saltpeter. Elfving,[31] Lauren,[32] Johannsen,[33] and Morkowine,[34] have demontrated the acceleration of respiration by anesthetics. Morkowine[35] has also extended Jacobi's work on the action of alkaloids. Mayer[36] reports that HCN reduces the activity of respiration, as

[30] KELLNER, O., Ueber einige chemische Vorgänge bei der Keimung von *Pisum sativum*. Landw. Versuchsst. **17**: 408. 1874. [Bot. Jahresb. **1**: 828. 1874].

[31] ELFVING, F., Ueber die Einwirkung von Aether und Chloroform auf die Pflanzen. Finska Vetensk. Soc. Förh. **28**: 36. 1886. I have not seen this paper.

[32] LAUREN, W., Ueber den Einfluss von Aetherdämpfen auf die Athmung von Keimlingen. Helsingfors. Diss. 1891. [Bot. Jahresb. **20**^{1}: 92. 1892.]

[33] JOHANNSEN, W., Aether- und Chloroformnarkose und deren Nachwirkungen. Bot. Centralbl. **68**: 337–338. 1896.

[34] MORKOWINE, N., Recherches sur l'influence des anesthésiques sur la respiration des plantes. Rev. Gén. Bot. **11**: 289–352. 1899.

[35] MORKOWINE, N., Recherches sur l'influence des alcaloides sur la respiration des plantes. Rev. Gén. Bot. **13**: 109, 177, 212, 265. 1901.

[36] MAYER, AD., Ueber den Einfluss der Blausäure auf Pflanzenathmung. Landw. Versuchsst. **23**: 335. 1879.

KCN is believed to do in animal physiology. Diakonow[37] states that with increasing acidity of the nutrient medium intramolecular respiration of molds decreases, but normal respiration is not sensibly affected. Kosiński[38] finds the respiration of Aspergillus quickened by Zn, Fe, Mn, cocain, strychnin, and not too concentrated ether; he tested $ZnSO_4$ as strong as 0.1 per cent. without its depressing the respiration during the first day. He also reports a stimulation by .0005 per cent. $ZnSO_4$, but this appearance is quite possibly due to the growth of his material, as appears more probable from his finding the acceleration not very dependent on the concentration of salt applied. Ono (*l. c.* 1900, p. 156) found that the proper concentration of $NiSO_4$ increased the formation of oxalic acid, but got a similar result with no other poison. The acceleration of fermentation by yeasts, by the presence of traces of poisons, is a very nearly related phenomenon.

In my measurements of respiration I have used a modification of the Pettenkofer method, which has enabled me to work with an assurance of reliable results not possible with apparatus hitherto used. Respiration varies rapidly with changes in temperature, and absolute constancy of temperature is not practicable. The best we have been able to do is to make the variations as slight as possible; and in studying the influence of other factors on respiration, the error from the thermal variations has had to be ignored. Working with water plants this error is augmented by the lesser solubility of CO_2 at higher temperatures. The rate at which air passes through the apparatus has a more than appreciable influence on the results under any conditions; and when working with solutions the solubility of the CO_2 makes glaring the results of small irregularities in the rate of flow. When experiments are lasting longer than a few hours the rate of respiration may change, and the possible error from this source is very imperfectly overcome when, with other plants, under conditions which it is hardly possible to make identical, the respiration is found constant.

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[37] DIAKONOW, N. W., Intramolekulare Athmung und Gährthätigkeit der Schimmelpilze. Ber. Deutsch. Bot. Gesells. **4**: 2–7. 1886.

[38] KOSIŃSKI, I., Die Athmung bei Hungerzuständen und unter Einwirkung von mechanischen und chemischen Reizmitteln bei *Aspergillus niger* Jahrb. Wiss. Bot. **37**: 137–204. 1901.

I had been but a few weeks at this work before irregularities in my results, which I could not prevent, and often could not account for—just such irregularities as cast a suspicion on more than one piece of work on respiration—made it very evident that sound results on respiration are not to be obtained without the same precaution in the use of parallel controls which is regarded as indispensable in other fields of physiology. So far as I know, the only work in which a real control has been used in experiments on respiration is that of Moller,[39] whose apparatus is in that respect more worthy of imitation than the widely followed one of Pfeffer and Wilson.[40]

The apparatus which I have used is illustrated by the accompanying diagram (*fig. 1*). The subjects of experiment are submerged in water in a large can. In the early part of the work, I used in place of this can a large stone churn, black inside, with a turned wooden lid soaked in India ink, and plugged the openings around the connections with cotton similarly soaked; but I have since satisfied myself that the light in the interior of the laboratory will not disturb the experiment if no care at all is taken to exclude it from the can. The air comes to both bottles of experiment material after the removal of all CO_2 by passing two towers of solid KOH and a solution of $Ba(OH)_2$. From each subject of experiment the air passes to a bottle, in whose stopper are four holes, which serves admirably, and without taking more than a minimum of room, as a switch board. When the experiments were carried on at a much higher temperature than that of the room, these bottles contained H_2SO_4 to prevent the dilution of the baryta water by distillation from the experiment bottles. In the diagram the absorption tubes are Winkler coils. I have used them and Pettenkofer tubes about equally, and have no choice, except that with the latter it is not easy to keep the glass tube by which the air enters the baryta water free of $BaCO_3$. It is not difficult to keep either kind of tube clean if it is always washed, after using, with *dilute* HCl. Using two absorption tubes with each culture, the experiment is continuous, only a few seconds being used in switching the currents of air. From the absorption tubes the air passes to another switch board bottle containing some H_2SO_4. A tube directly from one switch board bottle to the other makes it possible to keep air passing through the cultures without using the absorption tubes; but this was found inadvisable and was largely given up, because when the absorption tube is returned to use, the height of liquid in it slackens the flow of air, and the irregularity so introduced is not immediately overcome by lengthening the siphon by an equal height of liquid. The glass stop cocks to which the air passes next regulate its rate of movement. These cocks must be selected by experience, and once they are working well must not be touched. The H_2SO_4 in the bottles below them prevents their obstruction by the precipitation of water.

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[39] MÖLLER, H., Ueber Pflanzenathmung. Ber. Deutsch. Bot. Gesells. **2**: 306–321. 1884.

[40] PFEFFER, W., Ueber intramolekulare Athmung. Unters. Bot. Inst. Tübingen **1**: 636–685. 1885.

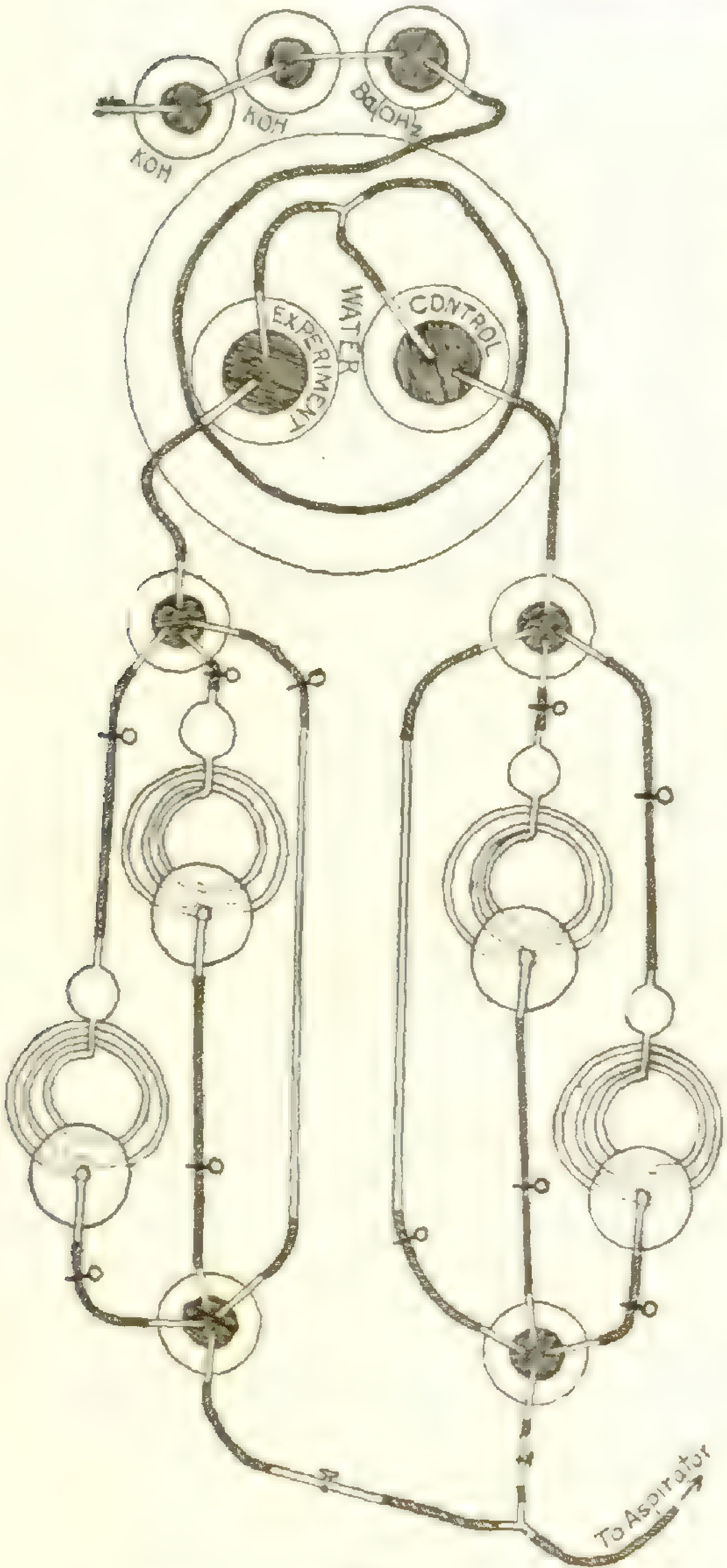

Fig. 1.

As aspirators I have used barrels, and latterly a metal cask holding 200 liters, the vessel always having a lateral bung so that it might lie on its side. With this aspirator it was possible to run air at the speed I chose, usually about three liters per hour, through both cultures for over thirty hours. It was always filled (the filling requiring but few minutes) the last thing at night, and the effect of the interruption was lost in the long interval before the next change of solutions. The volume of water in these aspirators was so great that the surface sank very slowly; and with a siphon over two meters long the loss of the effective pull was so slow that it could have had but little influence on the result if neglected; but even this I tried roughly to correct by lengthening the siphon as the day passed.

The siphon was a glass tube with the largest bore, almost 3^{mm}, with which the stream would be certain to carry down any bubble forming in it. The siphon could carry water from the aspirator so rapidly that the limited rate at which air enters the latter has no great influence on the pressure in it, and almost the whole pull of the siphon is exerted against each of the glass stop cocks. Any attempt to regulate the flow in the usual way, by restricting the siphon, reduces the suction in the aspirator; then the more rapid movement of air through one culture, the slower it is through the other. I have found it utterly impossible to balance the resistance in the two parts of the experiment so perfectly that they would keep the balance through the whole time of an experiment, except in the way described, by having the same high and steady suction act constantly on both.

The baryta water was put into the absorption tubes with the apparatus at the left of *fig. 2*. From the large bottle of stock solution it was allowed to run into the tube *A* until the fine tube in the top of this just broke the meniscus. The escape was then connected by a rubber joint with the small end of the absorption tube, and the liquid allowed to run out until the tube inserted in the lower end of *A* broke the meniscus; this measured out 100^{cc} without its coming in contact with any CO_2 except in the air in the absorption tube. Of course the stale baryta water standing in the escape of *A* was washed out just before the tube was filled. No baryta water was allowed to stand in the small bulb of the Winckler tubes.

After each interval of experiment the solution used was poured from the absorption tube into a bottle holding a little over 100^{cc}, without exposure to air except that in the bottle; and the bottle was immediately placed in the position of *B* in *fig. 2*, or else stoppered. If respiration had been active enough to form a visible precipitate, this was allowed to settle, and the solution then siphoned into *C*. As one-third of the baryta water used was ordinarily more than was needed for titration, I was

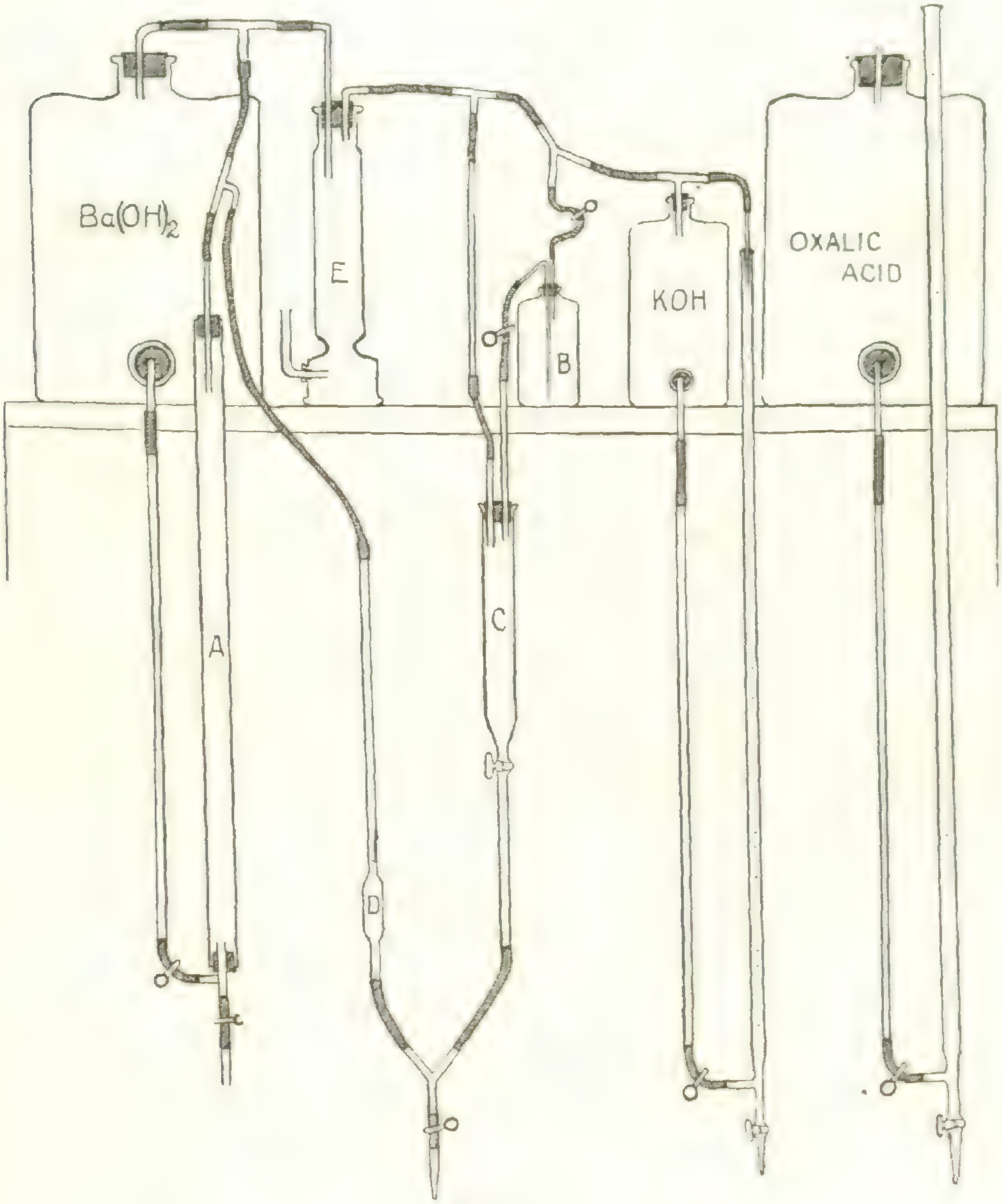

FIG. 2.

able to use it freely in washing out the apparatus before beginning to measure it. For the actual measurement I used the "burette" *D*, which I blew from heavy tubing with a bore of less than 3^{mm}; from the scratch above the bulb to that below is exactly 10^{cc}. The titrating was done in 100^{cc} bottles, with perforated corks. Two drops of neutral alcoholic phenolphthalein were put in the bottle, which was then corked; 10^{cc} of the solution to be tested were run from *D*, whose outlet was stuck through the cork; then the outlet of the burette containing oxalic acid was stuck through the cork and enough run in to just neutralize. The acid was run in cautiously enough so that the color disappeared with the final addition of a single drop; this made it unnecessary to titrate back, though a burette of KOH of the proper strength was always ready for use if needed. As the diagram (*fig. 2*) shows, every vessel of any kind containing an alkaline solution can communicate with the air only through the tower *E*, containing pumice soaked in KOH.

For the idea of this method of titrating I am indebted to Symons and Stephens.[41] When, as in this work, extreme accuracy is necessary, titrating in a flask closed with the thumb, as is directed in manuals of quantitative analysis, yields serious irregularities; and when the liquid to be tested is measured by a pipette into which it is sucked, the results are not even tolerably uniform. Using the common method I often made five determinations of the titre to get a "reliable" average. The first two are likely to agree entirely, and almost never vary by more than one drop (0.05^{cc}); when they agree I call any more tests superfluous. This accuracy is the more notable because the acid used was $\frac{N}{100}$. The usual method of determining the CO_2, in milligrams, has no recommendation except custom; expressing it in volume of a normal solution is in much better harmony with modern chemical methods. My acid was practically 0.44 as strong as the most dilute one commonly used, of which 1^{cc} is the equivalent of 1^{mg} CO_2. It permits therefore more than twice the accuracy.

The limit of positive accuracy in volumetric analysis is one drop of the strongest solution in use. The directions extant for making up the baryta water provide for its being several times as strong as the acid it is titrated with. To get the benefit of the use of very dilute acid I have also used weak baryta water, not more than twice as strong, at the most, as the $\frac{N}{100}$ acid, except in experiments in which I anticipated a tremendous evolution of CO_2. Such dilute baryta water still removes all CO_2 from the air.

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[41] SYMONS, W. H., and STEPHENS, F. R., Carbon dioxide. Its volumetric determination. Journ. Chem. Soc. London **69**: 869–881. 1896.

As subjects of experiments in this work I have used Cardamine, Callitriche, Ceratophyllum, Potamogeton, Elodea, tadpoles, and fish (an immature cyprinoid, not determined). Elodea and tadpoles were the subjects of extended series of experiments, the other plants and the fish being used but a few times, to be sure of the general validity of the results.

In three changes of residence since doing the work with tadpoles I have misplaced the detailed results of the individual experiments on them. The solutions used on them were all dilute enough not to be fatal during the time of experiment, and their results agree in all essentials with those yielded by similar work on Elodea. Single experiments with the chlorids of gold and platinum on tadpoles failed to show any influence on the evolution of CO_2, probably because they were used in too great dilution. With $CoCl_2$ the evolution of CO_2 was accelerated. The other chemicals employed, Zn, Cu, Cd, and Hg, were used again on Elodea. Because of this, and of the question I will present shortly as to the significance of any of the results with strong metallic poisons, I do not think it worth while to hunt up and publish the detailed results on tadpoles. Nor will I consume space with any considerable part of the detailed results on other subjects. In the work with animal subjects, solutions much too weak to kill them stimulated them to a visibly increased muscular activity. This was most pronounced, with relation to the toxicity of the several metals, with Cd, a little less by Cu, and least of all the substances used by Pt, in which the tadpoles were very sluggish, in spite of the acidity of the "$PtCl_4$" employed. It seemed to me, from a comparison of the results obtained at the same time on tadpoles and on Callitriche, that the excited muscular activity of the former did not produce a relatively greater evolution of CO_2; from which I concluded that the protoplasm of both was stimulated equally, the plant's response being, for obvious reasons, less conspicuous.

A study of the acceleration of respiration would be blind reading, without accompanying information on the toxicity of the chemicals used. By the fragmentary condition of our knowledge on this subject, I have been obliged to determine for myself the toxicity of these substances for the different organisms, and have compiled tables on the tadpole, Callitriche, and Elodea, of which the two former may be omitted, with the corresponding statistics on respiration. These experiments on Elodea were made with young growing tips, 2–4^{cm} long. The condition of the plant, dead or alive, was determined by trying to plasmolyze the youngest grown leaves in KNO_3. Relieved of details as to concentrations which do not seriously injure or are stronger than enough to kill, the results follow, the figures being the number of liters of solution in which one gram-molecule is imagined distributed.

$Pb(NO_3)_2$	Alive but hardly sound after 24 hours in $\frac{M}{10}$. Appears normal in $\frac{M}{25}$.
KCN	Dead in 30 hours in $\frac{M}{100}$, but alive in $\frac{M}{200}$.
KOH	Dead in 2 hours in $\frac{M}{100}$: in one test dead, in another almost so after 24 hours in $\frac{M}{200}$.
$NiCl_2$	Dead in 24 hours in $\frac{M}{100}$: somewhat unsound in $\frac{M}{200}$.
$ZnSO_4$	Dead in three hours in $\frac{M}{100}$: alive but unsound after 26 hours in $\frac{M}{200}$: sound indefinitely in $\frac{M}{500}$, below 20° C.
HCl	Dead in 15 hours in $\frac{M}{500}$: unsound after 24 hours in $\frac{M}{1000}$.
$CoCl_2$	Practically dead after 24 hours in $\frac{M}{10,000}$.
$Cd(NO_3)_2$	Almost dead after 24 hours in $\frac{M}{20,000}$: sound in $\frac{M}{40,000}$.
$CuSO_4$	Dead in 25 hours in $\frac{M}{20,000}$: alive in $\frac{M}{40,000}$.
$HgCl_2$	Sound after 5 hours in $\frac{M}{40,000}$, but dead in 30 hours in $\frac{M}{80,000}$.
$AgNO_3$	Dead in 24 hours in $\frac{M}{160,000}$: unsound in $\frac{M}{320,000}$.

These determinations were made at a temperature of about 20° C.

K is a shade less poisonous than Pb; Na, a little less still, compared as nitrates. With the tadpoles, Pb and Cd were more toxic than with Elodea, but Co is less so. $PtCl_4$ was not more toxic than could be ascribed to its acidity; gold chlorid was about equally so; and uranyl (nitrate) was about as toxic as Co. KCN was not tested on tadpoles, but would certainly not have been found harmless as with Elodea. My KCN was strictly *p. c.*, and was about 0.7 as alkaline as equivalent KOH. Their toxicity toward Elodea is about proportional to their alkalinity.

The modern work on the toxicity of inorganic salts to higher plants is not as conclusive and satisfactory in its botanical as in its chemical aspects. At least in large part it has been done without reference to the temperature. But I have found, as was *a priori* reasonable, that at 28° C., and still more at 37.5° C. (at which the temperature alone is fatal in time), Elodea succumbs much more readily than below 20° C. If an arbitrary time limit, say 24 hours, is placed on the experiment, it is evident that the higher the temperature the more toxic the substances tested will appear. Beside this, I have some evidence, though not enough to be conclusive, that at higher temperatures the adaptation to the poison does not increase in rapidity in proportion to the injurious action; when this is true, the plant may become adapted and thrive in a solution at a lower temperature, which at a higher would kill it.

The range of variation in apparently reliable statements as to the toxicity of the same substances with different organisms is nothing short of astounding. Kahlenberg and True place Cu, Fe, Ni, and Co on a par, as to their action on *Lupinus albus*. Heald[42] finds Ni and Hg equally toxic to Zea. Coupin[43] says $CuSO_4$ diluted to 1 (mol.?) in 700,000,000 checks the growth of wheat, while $AgNO_3$ acts likewise when 1 in 1,000,000, and

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[42] Heald, F. D., On the toxic effect of dilute solutions of acids and salts upon plants. Bot. Gaz. **22**: 125–153. 1896.

[43] Coupin, H., Sur la sensibilité des végetaux supérieurs à des doses très faibles des substances toxiques. Comptes Rendus, Paris 132:645–647. 1901. Coupin claims priority for the discovery that distilled water is not in itself a poison, having published it in 1900 (Cf. de Clèves, L'eau distillée, est-elle pure? in La Nature 28 1:196. 1900), and Dehérain and Demoussy (Compt. Rend. 132: 523–527. 1901), having repeated it. The fact was not new by some years when Kahlenberg and I did our work in 1898 (published in 1899).

$Pb(NO_3)_2$ when 1 in 100,000. From the Pb and Ni results Elodea (and Callitriche) would seem very resistant as compared with other flowering plants; and in fact the tabulated results as a whole justify that view. And yet it ranks with the most sensitive when treated with Hg or Ag.

[*To be concluded.*]

THE GENUS CRATAEGUS IN NEWCASTLE COUNTY, DELAWARE.

CHARLES S. SARGENT.

THESE notes are based on collections and observations of the genus Crataegus made during the last three years in Newcastle county, Delaware, by Mr. W. M. Canby.

CRUS-GALLI.

Stamens 10.

CRATAEGUS CRUS-GALLI Linnaeus.— Near Wilmington the typical form of this species is common. It is a glabrous tree with wide-spreading branches, obovate coriaceous leaves with the primary veins mostly within the parenchyma, 10 stamens, bright rose-colored anthers, and sub-globose or short-oblong dull crimson fruit which often remains on the branches late into the winter or until spring. The leaves on short lateral branches are clustered and erect, while the long and numerous spines mostly point downward. In the middle states, however, there are many perplexing forms of this species; some have more or less hairy corymbs; of others the fruit varies in size, shape, and brightness of color; of others the leaves are thinner, nearly always acute and sharply serrate, with more prominent veins, and occasionally individuals are found nearly destitute of thorns. Some of the most distinct of these varieties may be characterized as follows:

CRATAEGUS CRUS-GALLI **oblongata,** n. var.—Fruit oblong, often 2.5^{cm} in length, rather brighter colored than the fruit of the type; nutlets 1 or 2, acute at the ends, prominently or often only slightly ridged on the dorsal side, 10 to 11^{mm} long.

Meadow near Edgemoor, *W. M. Canby*, September 30, 1899, June 3, 1901; Pennsylvania, Dunham, Bucks county, *C. D. Fretz*, October 1901, September 1902.

CRATAEGUS CRUS-GALLI PYRACANTHIFOLIA Ait. Sargent, Silva N. Am. **13**: 39. *t. 637*.—In this form the nutlets are also often solitary and are more acute than those of the typical form. Common.

CRATAEGUS CRUS-GALLI **capillata,** n. var.—Leaves oblong-obovate, rounded or acute at the apex, finely serrate, thin but firm in texture, lustrous on the upper surface, pale on the lower surface, about 3.5^{cm} long, 1.5 to 2^{cm} wide. Flowers small, rarely more than $8–10^{mm}$ in diameter, in many-flowered slightly villose corymbs; stamens 10; anthers pale rose color; styles usually 1, rarely 2. Fruit subglobose to short-oblong, green slightly blotched with red; nutlets 1, rarely 2, obtuse at the ends, prominently ridged, 8 or 9^{mm} long, nearly as thick as long.

A tree $3–4^{m}$ in height, with a trunk covered with dark rough bark, spreading branches, and slender nearly straight branchlets villose when they first appear, bright chestnut-brown and lustrous during their first season, becoming reddish-brown the following year, and armed with slender slightly curved bright chestnut-brown ultimately gray spines $3–6^{cm}$ long. Flowers during the first week of June. Fruit ripens toward the end of October and soon falls.

In woods one mile east of Christiana on the Newcastle road, *W. M Canby*, June 1 and October 16, 1901, May 31, 1902. A specimen in flower collected by Mr. Canby in a meadow at the head of the Wissahickon Drive, Germantown, Pennsylvania, appears to belong to this variety.

CRATAEGUS CANBYI Sargent, BOT. GAZ. **31**: 3. 1901; Silva N. Am. **23**: 41. *t. 638*.

Stamens 20.

Crataegus Pennypackeri, n. sp.—Leaves obovate, acute and often short-pointed at the apex, gradually narrowed and cuneate at the entire base, finely serrate above, with straight or slightly incurved gland-tipped teeth, glabrous, membranaceous until after the petals fall; at maturity subcoriaceous, dark green and lustrous above, pale yellow-green below, $3.5–4^{cm}$ long, about 2^{cm} wide, with pale light yellow midribs and primary veins impressed on the upper surface and raised and prominent below; petioles slender, grooved, winged above by the decurrent base of the leaf-blades, $8–10^{mm}$ long; leaves on leading shoots mostly rhombic, short-pointed, more or less deeply divided into broad acute lateral lobes, $8–9^{cm}$ long, about 7^{cm} wide, their stout petioles wing-margined, 7–8^{mm} long, rather shorter than the foliaceous lunate acuminate coarsely glandular-serrate stipules. Flowers in compact many-flowered thin-branched compound corymbs covered with long scattered pale caducous hairs; calyx-tube narrowly obconic, the lobes narrow, acuminate, entire or occasionally obscurely glandular-serrate, reflexed after anthesis; stamens 20; styles 3–5. Fruit oblong, full and rounded at the ends, bright crimson marked by numerous large pale dots, 1–3^{cm} long, 8–12^{mm} wide; calyx prominent with a short tube, a broad deep cavity, and lanceolate lobes abruptly narrowed from broad bases, appressed; flesh thin, greenish, dry and mealy; nutlets 3–5, thick, obtuse, prominently ridged on the back, with a broad rounded ridge, 9–10^{mm} long.

An arborescent shrub 4–5^{m} high, with spreading branches and slender nearly straight or slightly zigzag branchlets marked by large oblong pale lenticels, pale yellow-green at first, light red-brown and lustrous during their first season, becoming gray-brown in their second year, and armed with many stout straight or slightly curved spines 5–6^{cm} long. Flowers from the middle to the end of May. Fruit ripens toward the end of September and in the beginning of October.

Banks of the spillway of Dean & Pillings's mill south of Stanton Station, *J. T. Pennypacker*, May 31, 1902, *W. M. Canby*, June 28 and Sept. 27, 1902.

PRUINOSÆ.

Stamens 20.

CRATAEGUS PRUINOSA K. Koch, Sargent, Silva N. Am. **13**: 68. *t. 648.*

Hedges, Eden Park, Wilmington, May and October 1899, May 1900, Elliott's Hill near Wilmington, October 1899; fields near Wilmington, May 1900; race bank below Stanton, September 1902; fence rows near Wilmington, September 1902, *W. M. Canby*. Common.

CRATAEGUS ARCANA Beadle, Biltmore Bot. Studies **1**^{2}: 122. April 1902.— Except by its slightly smaller flowers, I cannot distinguish from *Crataegus arcana*, of the elevated regions of western North Carolina, a common shrubby thorn of northern Delaware and eastern Pennsylvania, with thin leaves cuneate at the base except on vigorous shoots, twenty stamens, pale rose or light purple anthers, and fruits often obconic at the base and conspicuously swollen or mamillate below the middle.

Wood borders opposite Farnhurst, *W. M. Canby*, May, September, and October 1900; Pennsylvania, Chadsford, Chester county (with larger fruit), *W. M. Canby* and *B. H. Smith*, October 8, 1902; Sellersville, Bucks county, *C. D. Fretz*, May 1898, October 1899, May and September 1900, May 1901.

Stamens 10.

Anthers yellow.

Crataegus delawarensis, n. sp.—Glabrous. Leaves rhombic to ovate, acute, gradually narrowed below from near the middle or on vigorous shoots broadly cuneate at the entire base, divided above into three or four pairs of short acute lateral lobes and finely and sometimes double serrate, with gland-tipped teeth, membranaceous, light yellow-green on the upper surface, paler below, 5–6^{cm} long, 4–5^{cm} wide, with slender light yellow midribs and 3 or 4 pairs of thin primary veins arching to the points of the lobes; petioles slender, slightly wing-margined at the apex, grooved, glandular at first, with few small dark red deciduous glands, 2–3^{cm} long; stipules linear, acuminate, coarsely glandular-serrate, reddish, caducous. Flowers about 1.5^{cm} in diameter on slender pedicels, in 5–8-flowered compact thin-branched compound corymbs; bracts and bractlets oblong-obovate to linear, acute, glandular-serrate, reddish; calyx-tube narrowly obconic, the lobes broad, acuminate, coarsely glandular-serrate, reflexed after anthesis; stamens 10; anthers pale yellow; styles 3 or 4, surrounded at the base by a narrow ring of pale tomentum. Fruit in few-fruited erect clusters, subglobose, rather broader than high, obscurely angled, gradually narrowed below to the stout petiole, dark red, not pruinose, 1.1–1.2^{cm} broad; calyx sessile, with a broad shallow cavity and lobes gradually narrowed from broad bases, acute, closely appressed; flesh thin, green, dry and mealy; nutlets 3 or 4, thick, full and rounded at the ends, prominently ridged on the back, witha high rounded ridge, 7^{mm} long.

A slender shrub 1–2^{m} high, with erect stems and thin nearly straight branchlets at first light green, dull red-brown and marked by occasional large oblong dark lenticels during their first year, light gray-brown in their second season, and armed with few very slender straight or slightly curved dark red-brown spines 3–4^{cm} long. Flowers the end of May. Fruit ripens toward the middle of October and mostly falls before the end of the month.

Wood borders. Rare. Between Newport and Newcastle, *W. M. Canby*, September 1899, May and October 1900.

A well marked species in the Pruinosa group, distinguished by the pale yellow anthers of the 10 stamens, by the absence of a calyx-tube from the mature fruit, and by the thinness of the leaves.

INTRICATAE.

Crataegus apposita, n. sp.— Leaves oblong to oval, acute, acuminate or rarely round at the apex, cuneate at the base, glandular-serrate, above the middle usually doubly, with spreading teeth, below with small incurved teeth, or often entire near the base, slightly and irregularly lobed toward the apex, with short acute lobes; as they unfold coated above with soft pale deciduous hairs, at maturity thin but firm in texture, dark yellow-green on the upper surface, paler on the lower surface, 3.5–4^{cm} long, 2–3^{cm} wide, with slender 2–4 thin remote primary veins extending obliquely to the points of the lobes; petioles slender, wing-margined above, at first villose, soon glabrous, glandular with small scattered dark red glands, often red toward the base, 1.5–2^{cm} long; stipules oblong-obovate to linear, conspicuously glandular-serrate, caducous, leaves on vigorous shoots often ovate, acute, broadly cuneate and abruptly narrowed at the base into the wide wing of the short stout petiole, coarsely serrate, deeply 3–5-lobed, 5–6^{cm} long, 4–6^{cm} wide, their stipules foliaceous, lunate, coarsely glandular-serrate, 7–10^{mm} long. Flowers 1.5^{cm} in diameter on slender pedicels, in few usually 4–7-flowered glandular compound corymbs; bracts and bractlets oblong-obovate to linear, conspicuously glandular-serrate, turning red before falling, caducous; calyx-tube broadly obconic, glabrous, the lobes gradually narrowed from broad bases, acute, glandular-serrate, slightly hairy on the inner face, reflexed after anthesis; stamens 10; anthers pale yellow; styles usually 3. Fruit in drooping clusters, oblong-obovate, full and rounded at the apex, gradually narrowed below into the stout petiole, green until late in the season, then reddish or green more or less blotched with red, or occasionally when fully ripe light red or rarely yellowish-bronze color; calyx-tube elongated, prominent, with a deep narrow cavity, and spreading and appressed lobes coarsely serrate toward the apex; flesh thin, yellow-green, dry and mealy; nutlets usually 3, broad, obtuse at the ends, rounded and prominently ridged on the back, with a wide rounded ridge, 8–9 mm long.

A thin-stemmed shrub usually 1–2 m high, rarely taller and almost arborescent in habit, with slender spreading branchlets yellow-green tinged with red when they first appear, bright red-brown or purple-brown and marked by few large pale lenticels during their first season, becoming dark gray-brown or reddish-brown the following year, and armed with numerous very slender bright chestnut-brown spines mostly 4–6 cm long. Flowers the middle of May. Fruit ripens about the 10th of October.

Wilmington, May 13, 1899; banks of Brandywine creek above Thompson's Bridge, May 16, and September 23, 1899; north side of Bancroft's Dam, near Wilmington, and Rockford Park, Wilmington, October 9, 1899; banks of Brandywine creek, near Wilmington, May 16, 1900, *W. M. Canby.*

Very closely related to *Crataegus intricata* Lange, a common New England species, this Delaware thorn can be separated from it by the shape of the deeply lobed leaves of vigorous shoots, by the somewhat smaller size, and the color of the fruit, by the elongated tube of the mature calyx, by the more tree-like habit of some individuals, and by its more numerous and more slender spines.

Crataegus nemoralis, n. sp.—Leaves ovate to oval, acute, gradually or abruptly narrowed, slightly divided above the middle into acute lobes coarsely and except toward the base mostly doubly serrate with incurved glandular teeth, tinged with red when they unfold, and covered with long pale caducous hairs on the upper surface, and pale blue-green and sparingly villose on the lower surface, glabrous when the flowers open; at maturity thick and firm, dark green above, paler below, 4–5 cm long, 3–4 cm wide; on leading shoots broader, full and rounded at the base, and often deeply lobed; petioles slender, slightly grooved, at first villose-pubescent, soon glabrous, glandular with small scattered dark persistent glands, 1.5–2 cm long; stipules linear, lobed at the base, villose, coarsely glandular-serrate, early deciduous. Flowers 1.4 cm in diameter, on slender pedicels in compact few-flowered thin-branched glabrous compound corymbs; bracts and bractlets oblanceolate to linear, acuminate, closely glandular-serrate, like the inner bud-scales, often becoming bright red before falling; calyx-tube broadly obconic, glabrous, the lobes broad, acute or acuminate, laciniately glandular-serrate, reflexed after anthesis; stamens 10; anthers pale yellow; styles 3 or 4, surrounded at the base by a narrow ring of pale tomentum. Fruit erect, in few-fruited clusters, globose to subglobose or slightly obovate, about 1^{cm} in diameter, dark green until late in the season, becoming dark clear red when fully ripe; calyx prominent with a broad deep cavity, a short tube, and spreading mostly persistent acuminate lobes often serrate above the middle; flesh thin, greenish, dry and mealy; nutlets 3 or 4, thick, acute at the ends, prominently ridged on the back, with a broad often deeply grooved ridge, 7–8^{mm} long.

A tree-like shrub with stems sometimes 3–4^{m} in height and stout zigzag branchlets, light olive-green and glabrous when they first appear, dark purple or reddish-brown and marked by numerous small oblong pale lenticels during their first season, and dark gray-brown in their second year and armed with many slender chestnut-brown or purple spines usually pointed toward the base of the branch and 5–6^{cm} long. Flowers the middle of May. Fruit ripens in October and falls before the leaves.

Common along woody borders, often in rocky soil. Rockford Park, Wilmington, October 1899, May and October 1900 and 1901, *W. M. Canby.*

This thorn, which is common in northern Delaware, is closely related to *Crataegus Boyntoni* Beadle, of the southern Appalachian region, differing from that species only in its smaller flowers on more slender pedicels, in its fewer-flowered corymbs, in its rather thinner leaves, and in the different color and size of the fruit which is inclined to be short-oblong or obovate.

Crataegus cuprea, n. sp.—Glabrous. Leaves ovate to rhombic, acute or acuminate at the apex, gradually or abruptly narrowed and concave cuneate or full and rounded, or on vigorous shoots sometimes slightly cordate at the entire glandular base, sharply and often doubly serrate above with nearly straight gland-tipped teeth and divided into 2–4 pairs of short acute lateral lobes; nearly fully grown, membranceous and pale green when the flowers open, at maturity thin but firm in texture, dark yellow-green on the upper surface, pale on the lower surface, 5–7^{cm} long, 3.5–5.5^{cm} wide, with prominent midribs and few remote primary veins extending to the points of the lobes; petioles slender, usually wing-margined above, glandular with stipitate dark red glands often deciduous before the autumn, 1.5–2.5^{cm} long. Flowers about 1.2^{cm} in diameter, on short often glandular pedicels, in 3–5-flowered compact compound thin-branched corymbs; bracts and bractlets conspicuous, oblong-obovate, acute, or rounded at the apex, coarsely glandular-serrate, tinged with red; calyx-tube broadly obconic, the lobes elongated, abruptly narrowed from broad bases, enlarged, foliaceous and glandular-laciniate above the middle, mostly entirely below, reflexed after anthesis; stamens 10; anthers pale yellow; styles 3 or 4. Fruit subglobose to short-oblong, often somewhat narrowed at the base, when fully grown at first green, then russet or copper color, and at maturity sometimes dull red, marked by few large dark dots, 1^{cm} long, 8 or 9^{mm} wide; calyx prominent, with a broad shallow cavity and spreading lobes coarsely serrate above the middle and often wanting from the ripe fruit; flesh thin, dry, yellow-green; nutlets 3 or 4, thick, rounded at the ends, prominently ridged on the broad rounded back, $7–8^{mm}$ long.

A low-branched stoloniferous shrub sometimes 2^{m} high, with slender branchlets, green tinged with red when they first appear, bright red-brown, lustrous and marked by numerous large oblong pale lenticels during their first season, and dull reddish-brown in their second year, and sparingly armed with straight stout bright red-brown lustrous spines $3–4^{cm}$ long, or unarmed. Flowers about the 20th of May. Fruit ripens early in October.

Vacant lots, Wilmington, Delaware, September and October 1899, May 1900, *W. M. Canby.*

PUNCTATAE.

CRATAEGUS PUNCTATA Jacquin.—Banks of Brandywine creek below Smith's Bridge, May 1869; banks of White Clay creek below Stanton, 1902, *W. M. Canby.*

MOLLES.

Crataegus Tatnalliana, n. sp.—Leaves ovate to oval, acute, broadly cuneate, or on leading shoots rounded or rarely cordate at the entire base, divided above into short acute lobes and coarsely and usually doubly glandular-serrate; as they unfold light green and covered above with short lustrous white hairs, rather paler below and villose along the midribs and primary veins; at maturity membranaceous, dark yellow-green and scabrate on the upper surface, paler and glabrous on the lower surface with the exception of a few scattered hairs on the slender yellow midribs and 5 or 6 pairs of thin primary veins extending to the points of the lobes, 8–10^{cm} long, 5.5–6^{cm} wide; petioles slender, at first villose-pubescent, soon glabrous or rarely puberulous at maturity, 2.5–3^{cm} long; stipules spathulate, acute, conspicuously glandular-serrate, caducous, or on vigorous shoots foliaceous, full and rounded below, acuminate at the apex. Flowers 2^{cm} in diameter, in compact ultimately lax slender-branched many-flowered compound corymbs; bracts and bractlets foliaceous, oblong-obovate, acute or short-pointed at the apex, coarsely serrate, their teeth tipped with large bright red glands; calyx-tube broadly obconic, thickly coated like the short slender pedicels with long white hairs, the lobes acuminate, serrate, with elongated teeth tipped with red glands, dark green, slightly puberulous particularly along the lower side of the prominent midvein; stamens 10; anthers large, white; styles 3 or 4, surrounded at the base by a broad ring of white tomentum. Fruit in few-fruited drooping puberulous corymbs, globose, obovate or rarely oblong, full and rounded at the ends, bright orange-red, marked by large pale dots, puberulous toward the base, 1.5–2^{cm} long, 1–2^{cm} wide; calyx cavity broad and deep, the lobes gradually narrowed from broad bases, acuminate, coarsely serrate usually only above the middle, puberulous, bright red on the upper side toward the base, closely appressed or rarely erect and incurved; flesh thick, yellow, dry and mealy; nutlets 3 or 4, thin, acute at the narrow ends, very irregularly ridged on the rounded back, 7–8^{mm} long.

A shrub 4 or 5^{m} high, with numerous stout stems forming a broad head, and thick slightly zigzag branchlets at first villose, soon glabrous, dark red-brown, lustrous and marked by numerous large oblong white dots during their first season, becoming ashy gray and lustrous during their second year and ultimately darker, and armed wiih stout straight or slightly curved bright chestnut-brown shining spines 4–5^{cm} long. Flowers during the first week of May. Fruit ripens from the middle to the end of August and soon falls.

Hedge rows and wood borders. Near Newport, August 1899, May and August 1900; between Newport and Newcastle, September 1899 and 1900, *W. M. Canby*.

Well distinguished from previously described species of the Mollis group by the peculiar hairs which cover the calyx and pedicels of the flower, the large foliaceous bracts and bractlets of the corymb, by the foliaceous calyx-lobes, and by its habit. This common Delaware species may be fittingly associated in its name with Edward Tatnall, the author of the *Catalogue of the Phaenogamous and Filicoid Plants of Newcastle County, Delaware.*

LOBULATAE.

CRATAEGUS ARCTUATA Ashe, Ann. Carnegie Mus. **1**: 387. May 1902.—I doubtfully refer to this species, on the strength of the published characters, a common thorn of Newcastle county, Delaware, and of Bucks county, Pennsylvania. *Crataegus arctuata* is a large shrub or small tree with broad ovate acute membranaceous leaves divided into numerous short acute lateral lobes, flowers in wide many-flowered villose corymbs with 5–7 stamens and red anthers, and short-oblong subglobose fruit ripening toward the end of August and soon falling.

Hedges near Wilmington, May and September 1899; near Newport, May and August 1900; hedges near Wilmington, May 1900; fields south of Eden Park, May and October 1900, *W. M. Canby;* Pennsylvania, Sellersville, Bucks county, May, September and October 1901, *C. D. Fretz.*

The name *arctuata* was used in 1886 by Gandoger in his *Flora Europae* for one of his proposed species of his genus Oxyacantha (*Crataegus Oxyacantha* Linnaeus), but as Gandoger's names can hardly be taken up by botanists it does not now seem worth while to make a new name for Mr. Ashe's species.

TENUIFOLIAE.

CRATAEGUS TENELLA Ashe, Ann. Carnegie Mus. **1**: 388. May 1902.—Although I have been unable to see an authenticated specimen of the *Crataegus tenella* of Ashe described from material gathered in Delaware county, Pennsylvania, I refer provisionally, at least, to that species the common thin-leaved shrubby thorn of eastern Pennsylvania and Newcastle county, Delaware, with 5–7 stamens, pink anthers, and oblong or rarely pear-shaped bright scarlet lustrous fruits, with soft pulpy flesh, ripening early in September and often remaining on the branches until October.

Du Pont woods near Wilmington, September 7, 1899; border of marsh between Newport and Stanton, September 9, 1899; Newport, May 14, 1899; banks of Brandywine creek below Smith Bridge, May 16, 1899, *W. M. Canby;* Pennsylvania, Delaware county, woods below Castle Rock, May and September 1901; near Upper Darby, October 1901, May 1902; hill south of Castle Rock, May 1902, *B. H. Smith;* Bucks county, near Sellersville, September 1899, May and September 1901; near Telford, June 1899, *C. D. Fretz.*

Crataegus stolonifera, n. sp.—Leaves ovate-oblong, acuminate, rounded, truncate or sometimes slightly cordate at the broad base, more or less deeply divided into four or five pairs of acute or acuminate lobes, coarsely and often doubly serrate, with straight or incurved glandular teeth; as they unfold suffused with red and villose above, with long pale caducous hairs; at maturity thin but firm in texture, glabrous, dark yellow-green on the upper surface, pale on the lower surface, 4.5–6$^{\rm cm}$ long, 3–4$^{\rm cm}$ wide, with slender midribs slightly impressed above and 4 or 5 pairs of remote primary veins extending to the points of the lobes; petioles slender, slightly grooved, at first glandular, with numerous small dark deciduous glands, often red below the middle, 1.5–2$^{\rm cm}$ long; stipules linear, acuminate, finely serrate, bright red, caducous. Flowers 1.5$^{\rm cm}$ in diameter, in compact mostly 5–10-flowered thin-branched glabrous compound corymbs; bracts and bractlets oblong-obovate to linear, acuminate, finely glandular-serrate, bright red, caducous; calyx-tube narrowly obconic, the lobes acuminate, entire or slightly serrate toward the apex, often red toward the base, reflexed after anthesis; stamens 5–7; anthers small, dark red tinged with purple; styles 3 or 4, surrounded at the base by a narrow ring of pale tomentum. Fruit in few-fruited drooping clusters, usually on short pedicels, short-oblong to subglobose, scarlet, lustrous, 1–1.1$^{\rm cm}$ long; calyx cavity broad and shallow, the lobes gradually narrowed from broad bases, acuminate, mostly entire or sparingly serrate, red on the upper side toward the base, closely appressed; flesh yellow, thick and succulent; nutlets 3 or 4, thick, narrow and acute at the ends, prominently ridged on the back, with a thin high ridge, 7–8$^{\rm mm}$ long.

A shrub 2–3$^{\rm m}$ tall, with numerous stems spreading into broad thickets and slender slightly zigzag branchlets olive-green tinged with red when they first appear, dull red-brown during their first and olive-green during their second year, and armed with numerous stout slightly grooved bright chestnut-brown spines 3–5$^{\rm cm}$ long. Flowers from the 10th to the middle of May. Fruit ripens early in September and soon falls.

Rocky hillsides and the borders of swamps in rich moist soil. Between Newport and Stanton, May and September 1899; Clayton street and Delaware avenue, Wilmington, May and September 1899 and 1900, *W. M. Canby;*

Pennsylvania, meadows near Sellersville, Bucks county, May and October 1901, September 1902, *C. D. Fretz.*

In the shape, texture and color of the leaves this handsome species resembles the New England *Crataegus pastorum* Sargent, but differs from it in its smaller number of stamens and in its much larger subglobose earlier ripening fruit, and in habit.

PARVIFLORAE.

CRATAEGUS UNIFLORA Moench.—Not common.

CRATAEGUS CORDATA Aiton and the Old World CRATAEGUS OXYACANTHA Linnaeus are sparingly naturalized in Newcastle county.

ARNOLD ARBORETUM,
Jamaica Plain, Mass.

THE RAVENELIAS OF THE UNITED STATES AND MEXICO.

WILLIAM H. LONG, JR.

(WITH PLATES II AND III)

THE writer originally intended to include in this paper only the Texan species, but as the study advanced it became evident that many Mexican species would be found in Texas, probably all of them when the fungal flora of the extreme southern and southwestern section of the state is collected and studied; while in the eastern and northeastern counties the species of the southern Atlantic states would probably be found; so it was thought best to include in the present paper all known Ravenelias from the United States and Mexico.

The genus seems to be mainly tropical and subtropical, only two species being found above latitude 38°, viz., *R. opaca* and *R. epiphylla*, the latter being the most widely distributed subtropical species known, extending as far north as New York, westward to the Mississippi, and southward to Florida. The known species are distributed as follows: United States 11, Mexico 15, Central and South America 21, West Indies 1, South Africa 12, Ceylon 5, and Japan 1.

The Ravenelias are among the most natural and marked groups of all the Uredineae. So far as known they are confined entirely to the Leguminosae as to host, with two exceptions, viz., *R. appendiculata* and *R. pygmaea*, found on Phyllanthus. Most of the species on the Leguminosae are parasitic on the two suborders Caesalpinieae and Mimoseae.

The genus Ravenelia was founded by Berkeley, with *R. indica* and *R. glandulosa* as its first species. At that time, and for some years afterwards, the exact status of the genus was not known, as the general morphology of the plant and the germination of the teleutospores had not been studied. Later Parker[1] studied the morphology of one species, and Cunningham[2] worked on the life histories of two species. Duggar[3] investigated the germination of the teleutospores. In 1894 Dietel[4] published his excellent monograph of the genus. This included all the Ravenelias then known and gave a brief résumé of previous work, together with a rather full discussion of the characters of the various species, followed by systematic descriptions and plates to illustrate the various species. Since then many new species (about fifteen) have been described by various authors, most of them from the Americas. Much light was thrown on the general life-history, morphology, etc., by these investigations, and the true status of the genus was fully determined, all of its characters undoubtedly placing it with the Uredineae. Much careful work yet remains to be done, as all that is known of most of the species is a brief systematic description of the dried plant.

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[1] On the morphology of *Ravenelia glanduliformis*. Proc. Amer. Acad. **22**: 205–217. 1886.

The writer is under many obligations for specimens, etc., to Mr. E. W. D. Holway, Dr. P. Sydow, Dr. P. Hennings, Dr. P. Dietel, Dr. W. G. Farlow, Professor E. O. Wooton, Mr. S. B. Parish, Mr. Elam Bartholomew, Dr. D. Griffiths, Shaw Botanical Gardens, New York Botanical Gardens, Dr. J. C. Arthur, and the U. S. Dept. of Agriculture; also to Professor George F. Atkinson for his aid and advice throughout the prosecution of this work.

All drawings were made with the aid of an Abbé camera lucida from material that had been boiled in lactic acid to restore the spores to their natural size and shape and bring out details that would not otherwise be noted. In some instances only a small quantity of material of a given species was available. In such a case the question arose how best to utilize this to show all the essential characters. The method pursued was first to mount a bit in distilled water and allow the water to evaporate. In this condition all the minute surface markings of the spores are more plainly seen; but this preparation would not show the germ pores and would usually burst the cysts. Hence a second mount was found necessary, prepared as follows: A mixture of equal parts of 100 per cent. glycerin and 80 per cent. alcohol was made, and a glass slide was used on which a cell of white zinc had been made. It was found necessary to make the cells two layers thick in order to get the proper depth, putting on as much zinc each time as would stay without spreading too much; an interval of one to two hours between the putting on of the two layers is required. The slide was laid aside until the cell became dry and hard. In the center of this cell a scant drop of the glycerin and alcohol mixture was put; into this the spores, etc., were put; then a drop of 50 per cent. lactic acid was added and the slide heated over an alcohol lamp until the liquid came to a boil. In some cases it is necessary to boil it for a short time to make the germ pores show plainly. Care had to be taken not to boil so long as to burst the cysts, and yet to boil until the germ pores were visible; usually bringing the mixture to a boil accomplished the desired result. The mixture of alcohol and glycerin as given above prevents the bursting of the cysts, which usually happens in a water mount, while the acid makes the germ pores visible. After the preparation had cooled a cover glass was put on and sealed with white zinc. This makes a neat permanent mount, ready for instant use at any time, and shows practically all the desired details.

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[2] Notes on the life history of *Ravenelia sessilis* B. and *Ravenelia stictica* B. and Br. Scientific Mem. of Medical Officers of the Army of India, 1889.

[3] Germination of the teleutospores of *Ravenelia cassiaecola*. BOT. GAZ. 17: 144–148. 1892.

[4] Die Gattung Ravenelia. Hedwigia 33: 22–69, 367–371. 1894.

To ascertain whether the sori are subepidermal or subcuticular, microtome sections should be made. Most of the specimens will be dry and must be softened before they can be imbedded. A good method for softening the tissues is to place them in a mixture of equal parts of 65 per cent. alcohol and 100 per cent. glycerin; then heat this in the paraffin oven for twenty-four to forty-eight hours, at the end of which time the tissues will usually be soft and pliable; then wash in 65 per cent. alcohol for six hours; then run up and into paraffin in the usual manner. Bismarck brown or methyl blue makes a good stain for such preparations where the main object is to see the position of the sori. The cysts would often come through the entire process and show up beautifully in the Canada balsam mount.

The boiling in lactic acid is desirable for several reasons;

in addition to its bringing out the germ pores it swells the spores to their normal shape and size; drives out the air and makes them more transparent; by scattering the spores makes visible any uredospores or paraphyses that would otherwise be overlooked. By this means the uredospores of several species were found, of which hitherto only the teleutospore stage had been known.

Sometimes it is necessary to make a fourth preparation to see whether the teleutospores are all one-celled, or some two-celled; this will often be shown in the lactic acid mount where some of the teleutospore heads will be broken up; but in case this does not happen, it becomes necessary to macerate the material for twelve to twenty-four hours in a weak solution of caustic potash or even to boil it in this solution for a few minutes, when by pressure on the cover glass the heads will fall apart and the interior structure can be seen.

If permanent mounts are not desired, the cell feature can be omitted and the mount made on the slide direct. Usually freehand sections of the softened specimen will show the position of the sori in the leaf, and this can be done where a sufficient quantity of material is available; but where only a bit, and that of a type or rare species is at hand, it is best to use the microtome.

A study of the life history of the various species has not been attempted in this article. One species (*R. Holwayi*) was found whose aecidial stage differs from the type in that it is without a pseudoperidium. This species is placed in a new genus (Neoravenelia), distinguished from Ravenelia by its caeoma type of aecidia. The deep-seated character of the aecidiosori of this species is in marked contrast to the very shallow sori of the uredospores and teleutospores, which are usually between the cuticle and the epidermal cells or just beneath the epidermis. As the life history of the various species becomes better known, others in all probability will be found to have a caeoma type of aecidia, and will have to be transferred to Neoravenelia.

The genus naturally falls into two sections, according to the number of cells in the teleutospores. The first section (Ravenelia) includes all species in which all the teleutospores in a head are one-celled; the second section (Pleoravenelia) includes all species in which the inner teleutospores of a head are two-celled. As a matter of convenience it seems desirable to recognize these two sections as distinct genera.

KEY TO GENERA.

All teleutospores in a head one-celled; aecidia when present with a well developed pseudoperidium	*Ravenelia*
Inner teleutospores in a head two-celled; aecidia as in Ravenelia	*Pleoravenelia*
All teleutospores in a head one-celled; aecidia without a pseudoperidium	*Neoravenelia*

RAVENELIA Berk.

Berkley, Gardeners' Chronicle **10**: 132. 1853.

Parker, The Morphology of *Ravenelia glanduliformis*. Proc. Amer. Acad. **22**: 205–217. 1886.

Cooke, The genus Ravenelia. Jour. Roy. Micr. Soc. **3**: 384. 1880.

Duggar, Germination of the teleutospores of *Ravenelia cassiaecola*. Bot. Gaz. **17**: 144–148. 1892.

Dietel, Die Gattung Ravenelia. Hedwigia **33**: 22–69, 367–371. 1894; Engler and Prantl. Nat. Pflanz. **11**: 73–75. 1897–1901.

Spermogonia formed between the cuticle and the epidermal cells, hemispherical. Aecidia with a well developed pseudoperidium. Uredospores borne singly on short stalks, with germ pores few or many; paraphyses usually present in the uredosori. Teleutospores united into cushion-like heads, formed of several or many cells; all teleutospores in a head one-celled; attached to the under side of the heads are several to many hyaline cells or cysts; pedicel of the head composed of several hyphae, which are either united into a compound stipe or separate.

KEY TO SPECIES.

1.	Teleutospore heads smooth	2
	Teleutospore heads rough, spinous, warty, etc.	8
2.	Uredospore germ pores many, scattered	3
	Uredospore germ pores equatorial in one row	5
	Uredospore germ pores in two rows	6
	Uredospores unknown	7
3.	Sori sub-cuticular; cysts pendent	4

4.	Cysts peripheral; paraphyses many, clavate-capitate	*R. texana*
	Cysts beneath entire head; paraphyses few, hypha-like	*R. Longiana*
	Cysts beneath entire head; paraphyses none; pedicel stout, fulvous	*R. indica*
5.	Sori sub-epidermal germ pores 4; cysts pendent many	"*R. Holwayi.*"
6.	Uredospores brown, with a row of 4 germ pores on either side of equator	*R. siliquae*
	Uredospores fulvous, base hyaline to semi-hyaline, 4 germ pores in equator and 4 in a row near base	*R. versatilis*
7.	Sori sub-cuticular; heads chestnut brown	*R. Farlowiana*
	Sori sub-epidermal; heads black, opaque	*R. opaca*
8.	Uredospore germ pores many, scattered	9
	Uredospore germ pores 4, equatorial	12
	Uredospore germ pores 8, in two rows on either side of equator	*R. siliquae*
9.	Sori sub-cuticular; cysts peripheral	10
	Sori sub-cuticular; cysts not peripheral	11
	Sori sub-epidermal; cysts coherent; III heads densely warty.	*R. verrucosa*
10.	Cysts pendent; heads minutely verrucose	*R. expansa*
	Cysts pendent; heads several with long (5–8 μ) brown papillae on each spore	*R. mimosae-sensitivae*
11.	Stipe long, persistent, fulvous; papillae few, scattered	*R. cassiaecola*
	Stipe short, hyaline; papillae few, scattered	*R. mesillana*
	Stipe short, hyaline; III heads with several short papillae to each spore	*R. fragrans*
	Stipe short, hyaline; III with one (2–7 μ) papilla to each spore.	*R. spinulosa*
12.	Sori sub-epidermal; each spore of III heads armed with a stout appendage which is branched at apex	*R. appendiculata*
	Sori sub-epidermal; each spore of III heads armed with a curved hyaline spine (1–6 μ)	*R. arizonica*
	Sori sub-cuticular; cysts not pendent, peripheral; uredospores 18–20 by 22–25 μ	*R. mexicana*
	Sori sub-cuticular; cysts pendent, peripheral; uredospores 15–18 by 35–40 μ	*R. leucaenae*

RAVENELIA TEXANA Ell. and Galw., Jour. Mycol. **6**: 2. 83. 1890; Jennings, Bull. Tex. Agr. Exp. Sta. **9**: 1890.—*Fig. 1.*

Ravenelia texensis Dietel, Hedwigia **34**: 42–43, 63–64. 1895; Saccardo Syll. Fung. **11**: 210. 1895.

Sori breaking forth between the cuticle and the epidermal cells on both sides of the leaves, and sparingly on the leaf stems,

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[5] See *Neoravenelia Holwayi.*

small. Uredosori not present in material examined; uredospores oval to spheroid, light brown, spinulose, 13–20 by 16–20 μ, germ pores many, scattered; paraphyses hyaline to fulvous, clavate to capitate, 50–70 μ long, 10–20 μ thick; heads fulvous. Teleutospore heads dark brown, smooth, irregularly orbicular, 60–70 by 20–35 μ thick; 5–6 spores in cross-section, each 16–20 by 30 μ, tops dark brown; cysts oblong to ovate, hyaline, pendent, peripheral, swelling and bursting in water; pedicel hyaline, short.

On Desmanthus or Cassia: College Station, Texas, 1889. Leg. *Brunk* and *Jennings*.

RAVENELIA LONGIANA Syd., Hedwigia **40**: 128. 1901.—*Fig. 2.*

Sori breaking forth between the cuticle and the epidermal cells; on both sides of the leaves. Uredosori cinnamon-brown, orbicular, 0.5–1$^{\mathrm{mm}}$ in diameter, often confluent over wide areas, mainly on the under side of the leaves; uredospores obovate, oval or spheroid, spinulose, light brown, 20–33 by 23–26 μ; germ pores many, scattered; paraphyses present in the uredosori; few, semi-hyaline, hypha-like, walls much thickened. Teleutosori large, black, orbicular, 1–2$^{\mathrm{mm}}$ in diameter, on both sides of the leaves; teleutospore heads chestnut-brown, smooth, irregularly orbicular, 75–90 by 25–33 μ thick; 6–8 spores in cross section; cysts hyaline, spheroid to pyriform, beneath entire head, crowded, diameter about 16 μ; pedicel hyaline, compound, short.

On *Cassia Roemeriana*: Austin, Texas, Nov. 15, 1897 (type material for III spores); Aug. 24, 1901, no. 1019 (type for II sori). The type material for this species had no uredosori on the leaves, but a few uredospores were intermixed with the teleutospores. In August 1901, the writer collected the uredosori for the first time; the under side of the leaves of the host was nearly covered with the sori, while the upper surface was comparatively free.

RAVENELIA INDICA Berkeley, Gard. Chron. **10**: 132. 1853. Cooke, Jour. Roy. Micr. Soc. **3**: 385. 1889; Saccardo, Syll. Fung. **7**: 772–773. 1888; Dietel, Hedwigia, **33**: 51–52, 60. 1894; Holway, BOT. GAZ. **31**: 336. 1901.—*Fig. 4.*

Sori breaking forth between the cuticle and the epidermal cells. Uredosori on both sides of the leaves, often irregularly grouped around a central sorus, cinnamon-brown; uredospores ovate to globose, spinulose, pale yellow, 13–17 by 17–20 μ; germ pores many, scattered; paraphyses none. Teleutosori on the leaf stems and on the branches, forming somewhat swollen places of 4–6^{mm} in diameter, chestnut-brown; teleutospore heads orbicular, smooth, light brown, 60–85 by 33–40μ thick; 4–6 spores in cross section, each 16–22μ broad; cysts firm, persistent, flask-shaped, hyaline, 15–18μ in diameter, hanging in a cluster around the pedicel, beneath the entire head; pedicel stout, persistent, compound, fulvous, 95–150 by 20–25μ.

On *Cassia absus:* Tequila, Mexico, Sept. 29, 1893. Leg. *Pringle.*

Ravenelia siliquae, n. sp.—*Fig. 7.*

Sori breaking forth between the cuticle and the epidermal cells. Uredosori orbicular, large, 1–4^{mm} in diameter, cinnamon-brown, prominently surrounded by the ruptured cuticle, scattered or more or less confluent; uredospores fulvous, epispore densely verrucose, oblong-oval to ovate-fusiform, 13–17 by 20–33μ, usual size 16 by 30μ; germ pores 8, in two rows of 4 each, one row on either side of the equatorial zone; paraphyses very rare, hyaline or slightly fulvous at the apex, clavate, 43 by 7μ.

On pods of *Acacia farnesiana:* Etla, Oaxaca, Mexico, Oct. 25, 1899, no. 3841, *Holway.* Mr. Holway writes that this species was found only on the pods, the leaves being free from the rust. The peculiar position of the germ pores of the uredospores is such a marked character that the writer did not hesitate to establish a new species, as no other known Ravenelia has this character. No teleutospores were present in the material examined.

RAVENELIA VERSATILIS (Peck) Dietel, Hedwigia **33**: 38–42, 64, 368–369. 1894; Saccardo, Syll. Fung. **11**: 210–211. 1895.—*Fig. 3.*

Uromyces versatilis Peck, BOT. GAZ. **7**: 56. 1882; Saccardo, Syll. Fung. **7**: 582–583. 1888.

Ravenelia decidua (Pk.) Holway, Dietel in Hedwigia **33**: 370. 1894; Saccardo, Syll. Fung. **11**: 211. 1895.

Uromyces deciduus Peck, Reg. Rept. **45**: 25. 1891.

Sori breaking forth between the cuticle and the epidermal cells, on both sides of the leaves. Uredosori small, ochreous, thickly covering the leaves and often the leaf stems and branches; upper half of spores brown and somewhat thickened at apex, with spinules less prominent than those of the lower part; lower half fulvous to sub-hyaline, rugose-echinulate; elliptical to elliptical-ovate, 27–33 by 14–17 μ; germ pores 8 in two rows, one row of 4 germ pores in the equator, the other row near the base of the spore; paraphyses numerous, light yellow to semi-hyaline, clavate to capitate; pedicel hyaline, 50–60 μ long; heads 13–20 μ in diameter, very variable in shape. Teleutosori dark brown, on both sides of the leaves, small, 1 ^{mm} or less in diameter, oval to orbicular; teleutospore heads brown, usually smooth, but margin of some of the fully mature spores sometimes faintly verrucose, orbicular to oval, 83–100 μ in diameter; 6–8 spores in cross section, marginal spores 10–12, spores 40–45 by 16–18 μ, with apex brown for 4–5 μ; cysts hyaline, peripheral, oblong-ovate, few, 24–30 μ, swelling and finally bursting in water; pedicel compound, short, slightly fulvous, deciduous.

On *Acacia Greggii:* Gillespie co., Texas, *Jermy* 557 (U. S. Dept. Agr.); Tucson, Arizona, Aug. 1892, *J. W. Toumey*; San Bernardino, Cal., June 4, 1894, *Parish* 3377; Mescal mts., Arizona, May 24, 1890, *M. E. Jones.*

This is one of the very widely distributed Ravenelias as the above citations show. It is also a very marked and easily recognized species, as its uredospores are very characteristic, having two rows of germ pores, one in the equator and the other near the base of the spore, the lower half usually being hyaline or nearly so, and when boiled in lactic acid the lower half swells up and the outer part of the epispore appears gelatinous, giving the entire spore somewhat the appearance of an acorn in its cup, the upper half representing the acorn and the lower the cup.

In all the material examined except the Texan specimen, only uredosori were present, with an occasional teleutospore; the Texan specimen on the other hand was teleutospore material with only a few uredospores intermixed. A sufficient number were present, however, to fully identify the plant and to show all the peculiar characters of the typical uredospores of *R. versatilis.* The Texan plant was reported on *Acacia filicina* Willd., which proved on comparison with authentic specimens to be not *A. filicina* but *A. Greggii.* This comparison was made by the writer at the Missouri Botanic Garden, St. Louis, with Jermy's original collection from near San Antonio, Texas. Even the plant in the herbarium was infected with the rust. The species heretofore called *R. decidua* (Peck) Holw. proved on careful comparison to be in every respect identical with *R. versatilis* (Pk.) Diet. It is reported on all specimens examined as being on *Prosopis pubescens*, but a comparison of authentic specimens of this species with the host proved the previous determinations to be erroneous, and the host to be *Acacia Greggii.* Type material of *R. decidua* was examined and compared with authentic specimens of *R. versatilis*, with the above results both as to hosts and parasites.

RAVENELIA FARLOWIANA Dietel, Hedwigia **33**: 369. 1894; Saccardo, Syll. Fung. **11** : 211. 1895.—*Fig. 6.*

Sori breaking forth between the cuticle and the epidermal cells, mainly on the upper surface of the leaves and sparingly on the leaf stems. Uredosori and uredospores not present. Teleutosori orbicular, large, 4–5^{mm} in diameter, dark brown, when old with heads densely compacted into a crust-like layer, when young with a central sorus surrounded by a circle of spores, usually solitary; paraphyses none. Spermogonia present, chestnut-brown, about 100μ in diameter, subcuticular. Teleutospore heads very irregular in shape and in size, chestnut-brown, usually smooth but an occasional head with small warts on the margin, 50–106 by 40μ thick, usual size 75–95μ; spores 5–8 in cross section, very irregular in shape and size; cysts hyaline, peripheral, oblong ovate, with bases closely appressed to under side of heads, swelling and bursting in water; pedicel short, hyaline, deciduous.

On *Acacia anisophylla* and *A. crassifolia:* Mexico, *Pringle.* Specimens examined from herb. of Dr. Farlow.

RAVENELIA OPACA (Seym. and Earle) Dietel, Hedwigia **34**: 291. 815; Saccardo, Syll. Fung. **14** : 363. 1899.—*Fig. 5.*

Ravenelia indica forma *opaca* Seym. and Earle, Econ. Fungi no. 203.

Sori subepidermal, scattered or solitary on both sides of the leaves but mainly on the upper surfaces. Uredosori and uredospores not present. Teleutosori black, shining, large, 1–2^{mm} in diameter; teleutospore heads black, opaque, orbicular, smooth, 80–120μ in diameter; 5–6 spores in cross section, spores 20–26 by 33μ, apex intensely black-brown for 7–10μ; cysts globose, hyaline, pendent around the pedicel, swelling and bursting in water. Pedicel long, compound hyaline.

On *Gleditschia triacanthus:* Clear Creek, Union co., Ill., *F. S. Earle,* Aug. 13, 1890.

RAVENELIA VERRUCOSA Cke. and Ell., Jour. Mycol. **3**: 83. 1887; Grevillea **15**: 112. 1887; Saccardo, Syll. Fung. **7**: 772. 1888; Dietel, Hedwigia **33**: 41–42, 66. 1894.—*Fig. 9.*

Sori subepidermal, on both sides of the leaves but mainly on the upper surface. Uredospores intermixed with the teleutospores, brown, spinulous, oval to globose, 15–18 by 17–20μ; germ pores many, scattered; paraphyses many, cylindrical, hypha-like, chestnut-brown, 45–60 by 7 μ, bases hyaline. Teleutosori black, 0.5–1$^{\text{mm}}$ in diameter, more or less covering the surface of the leaves; teleutospore heads chestnut-brown, opaque, irregularly orbicular, 75–100 by 35–40 μ; 4–8 spores in cross section, spores with many short hyaline papillae to each spore; cysts coherent and decurrent into the hyaline pedicel, peripheral; pedicel short, hyaline, deciduous.

On *Leucaena lanceolata*: Watson no. 6, *Dr. E. Palmer*, 1886. The host was determined by Dr. J. N. Rose, U. S. National Museum.

Ravenelia expansa Diet. and Holw., Bot. Gaz. **23**: 35. 1887; Saccardo, Syll. Fung. **14**: 364. 1899.—*Fig. 10.*

Sori breaking forth between the cuticle and the epidermal cells, on both sides of the leaves, in large pallid spots which are specially prominent on the under side of the leaves. Uredosori rare, ochraceous, small; uredospores fulvous, spinulose, globose to subglobose, 17–20 by 20 μ; germ pores many, scattered; paraphyses clavate, heads fulvous, 13–16 by 26 μ; pedicel hyaline, about length of head or often shorter. Mature teleutosori chestnut-brown, large, up to 2$^{\text{mm}}$ in diameter, surrounded by the ruptured cuticle; teleutospore heads orbicular, verrucose, light brown, 70–90 by 35–40 μ thick; 5–7 spores in cross section, each crowned with several short, hyaline warts; cysts hyaline, pendent, oblong ovate, peripheral, 7–10, easily swelling and bursting in water; pedicel hyaline, short, compound, deciduous.

On *Acacia tequilina* Wats.: Guadalajara, Mexico, Oct. 13, 1896 (type), *Holway*.

Ravenelia mimosae-sensitivae P. Henn., Hedwigia **35**: 246. 1896.—*Fig. 11.*

Sori breaking forth between the cuticle and the epidermis, on both sides of the leaves, thickly distributed over the leaf surface. Uredosori cinnamon color, often in a circle around a central sorus; uredospores light brown, densely spinulose, ovate to spheroid, 20–22 by 23 μ; germ pores many, scattered; paraphyses broadly clavate to subcapitate, 13–20 by 50–60 μ; heads fulvous, pedicel and base of head hyaline. Teleutosori small, scattered, black; teleutospore heads orbicular to oval, black-brown, 65–80 by 33 μ thick; spores 4–6 in cross section, each crowned with several long (5–8 μ) brown papillae, apex somewhat thickened for 5–6 µ, spores 33–35 by 16–20 µ; cysts hyaline, ovate to spheroid, about 20 µ in diameter, peripheral, 6–10; pedicel short, hyaline, deciduous.

On *Mimosa albida:* Cuernavaca, Mexico, Sept. 24 and 29, 1899, *Holway.* Through the kindness of Dr. Hennings the writer was enabled to compare the Mexican form with type material from South America, and the two proved to be the same species.

RAVENELIA CASSIAECOLA Atkinson, BOT. GAZ. **16**: 313. 1891; Dietel, Hedwigia **33**: 50–51, 60–61. 1894; Duggar, BOT. GAZ. **17**: 144–148. 1892; Saccardo, Syll. Fung. **11**: 212. 1895; Atkinson, Bull. Cornell Univ. Science **3**: 20. 1897; Underwood and Earle, Bull. 80, Ala. Agr. Exp. Sta. 217–218. 1897.—*Fig. 12.*

Sori breaking forth between the cuticle and the epidermal cells. Uredosori mainly on the leaves, on both sides, small, 1^{mm} or less, cinnamon colored; uredospores broadly ovate to globose, fulvous or hyaline, minutely echinulate, 14–17 by 16–18 µ; germ pores many, scattered; paraphyses none. Teleutosori on the stems, black-brown, large, often confluent for several centimeters; teleutospore heads fulvous to chestnut-brown, 30–100 µ, usual size 60–80 µ; 4–6 spores in a cross section, usually with a short hyaline point to each spore; cysts hyaline, firm, globose, 14–18 µ in diameter, pendent, beneath the entire head; pedicel compound, persistent, fulvous, 60–110 µ long.

On *Cassia nictitans:* Auburn, Ala., 1891, *Atkinson*, also 1893, *Duggar;* Starkville, Miss., Sept. 19, 1892, *Ellis* and *Everhart*, N. A. F. 2d series, no. 2880, also Sept. 19, 1891, *Seymour* and *Earle*, E. C. Fung. Suppl. no. 325.

RAVENELIA MESILLANA Ell. and Barth., Bull. Torr. Bot. Club **25**: 508. 1898; Saccardo, Syll. Fung. **16**: 323. 1902.—*Fig. 13.*

Sori breaking forth between the cuticle and the epidermal cells, mainly on the upper surface of the leaves. Uredosori not present in material examined, but uredospores intermixed with teleutospores; uredospores light brown, broadly oval to globose, spinulose, 20–23 by 17–20 µ; germ pores many, scattered; paraphyses none. Teleutosori orbicular, crowded and often confluent, more or less covering the upper surface of the leaves, black-brown; teleutospore heads chestnut-brown, irregularly orbicular, an occasional head with one or two short papillae on its surface, 50–75 by 30–35 μ thick; 4–6 spores in cross section; cysts hyaline, globose, many, beneath the entire head, 15–18 μ in diameter; pedicel compound, short, hyaline.

On *Cassia bauhinioides:* Mesilla Park, N. M., Oct. 1897, *E. O. Wooton* (type ex. Herb. E. Bartholomew); same station and collector, October 1895 (ex. Herb. A. & M. College, N. M.).

Ravenelia fragrans, n. sp.—*Fig. 14.*

Sori breaking forth between the cuticle and the epidermal cells, small, scattered or often densely confluent on the leaves and leaf stems. Primary uredosori usually densely confluent on leaves and stems and young branches, causing them to become swollen and collected into globose bundles or "witches' brooms," 0.5–2$^{\text{cm}}$ in diameter; later uredosori more or less scattered over the leaves, often densely confluent over the entire surface of the young pods, tawny, sori small, usually less than 1$^{\text{mm}}$ in diameter and on both sides of the leaves; uredospores fulvous, walls thick, primary spores globose, often angular, later ones oval to globose, densely spinulose, 13–17 by 17–23 μ; germ pores many, scattered; paraphyses very abundant, clavate, 40–50 by 5–12 μ, heads fulvous, pedicel hyaline. Teleutosori small, less than 1$^{\text{mm}}$, black-brown, on both sides of the leaves and on the leaf stems; teleutospore heads chestnut-brown, papillate, orbicular, 70–85 by 30–35 μ thick; spores 5–6 in cross section, each with several (3–4) short hyaline papillae, 17–20 by 33–38 μ, tips intensely dark brown for 7 μ; cysts ovate-oblong, hyaline, beneath entire head, pendent; pedicel hyaline compound, short, deciduous.

On *Mimosa fragrans:* Austin, Texas, June 7, 1901, no. 142.

This species is very closely related to *Ravenelia expansa,* but differs from it in the cysts being beneath the entire head, while in *R. expansa* they are only under the marginal spores; the paraphyses are narrower and more abundant, and the uredospores are darker and more elliptical than those of *R. expansa.* This rust was collected during June and July; very few teleutosori were present; by the close of July all the infected leaves had fallen from the host.

RAVENELIA SPINULOSA Diet. and Holw., BOT. GAZ. **31**: 336. 1901.—*Fig. 15.*

Sori breaking forth between the cuticle and the epidermal cells, on both sides of the leaves. Uredosori ochre color, often confluent in effused patches, 0.5–1 mm in diameter; uredospores oval to spheroid, densely echinulate, light brown, 17–20 by 20–30 μ, usual size 18 by 25 μ; germ pores many, scattered; paraphyses rare, capitate-clavate, much attenuated toward base, hyaline, 10–15 by 30–50 μ. Teleutosori black-brown, small, scattered; teleutospore heads chestnut-brown, papillate, irregularly orbicular, 50–120 by 30–40 μ thick; 5–7 spores in cross section, each with a single hyaline (2–7 μ) papilla; cysts hyaline, globose, 13–15 μ in diameter, pendent, beneath the entire head; pedicel short, hyaline, deciduous, compound.

On *Cassia Lindheimeriana:* San Marcos, Texas, Nov. 19, 1901; Marble Falls, Texas, March 30, 1901; Austin, Texas, Aug. 24, 1901, no. 1026; Austin, Texas, Oct. 5, 1901, leg. *A. M. Ferguson.*

On *Cassia multiflora*: Oaxaca, Mexico, Oct. 18, 1899, no. 3675 (type) *Holway.*

RAVENELIA ARIZONICA Ell. and Ev., Bull. Torr. Bot. Club **22**: 363–364. 1895; Saccardo Syll. Fung. **14**: 367. 1899.—*Fig. 16.*

Sori subepidermal, on both sides of the leaves but mainly on the under side. Uredosori chestnut-brown, firm, scattered, 0.5–1 mm broad, oval to orbicular; uredospores obovate to oblong-ovate, spinulose, light brown, apex often darker, 17–20 by 28–36 μ; germ pores 4, equatorial; paraphyses of two kinds, normal form capitate, heads dark brown, walls thick: pedicel usually hyaline, somewhat attenuated toward base; heads 20–23 μ in diameter, pedicels 30–60 by 7 μ; the other form cystoid, walls thin, clavate-fusiform with apex nipple-shaped, slightly fulvous, rare. Teleutosori dark brown, orbicular, 80–100 μ in diameter, spinous; 6–8 spores in cross section, tips intensely brown for 6 μ, 10–15 by 25–33 μ, each crowned with a curved hyaline spine 4–6 μ long; cysts hyaline, spheroid in a dense cluster beneath the head, pendent, swelling and bursting in water; pedicel compound, hyaline, short, deciduous.

On *Prosopis juliflora:* Abilene, Texas, 1900, no. 1481, Ell. and Ev. Fung. Col. continued (issued as *R. decidua* (Pk) Holw.).

On *Prosopis velutina:* Tucson, Ariz., no. 37, *J. W. Toumey* (type); also Oct. 21, 1894, *J. W. Toumey;* Nov. 1900, no. 252 and no. 252a, West Am. Fung.

The no. 252a of West American Fungi is very interesting, as the uredospores are borne on large woody galls, which are densely covered with the confluent sori; the spores on these vary greatly in shape and size. The galls, Mr. Griffiths writes me, are perennial, bearing successive crops of uredospores year after year. The teleutospores are on the leaves of the same trees that have the uredospore-bearing galls, but no teleutospores were found on the galls. This gall-bearing stage is very similar to the aecidial stage of *Neoravenelia Holwayi*, only in this case the spores are not in chains, but are true uredospores and are intermixed with the characteristic paraphyses. The galls also are larger and woody, while those of *Neoravenelia Holwayi* are brittle, and shrink very much in drying, and are annual.

This species was originally reported as on *Prosopis juliflora;* but this, Dr. David Griffiths writes me, was an error, as the host is *Prosopis velutina* Wooton.

RAVENELIA APPENDICULATA Lagerh. and Diet., Hedwigia **33**: 47, 65. 1894; Saccardo, Syll. Fung. **11**: 210. 1895.—*Fig. 8.*

Sori subepidermal, mainly on the under side of the leaves, scattered. Uredosori cinnamon color, small; uredospores fulvous to hyaline, ovate, verrucose, 20–23 by 26–30 μ, germ pores four, equatorial; paraphyses clavate, stout; heads evenly brown, 17–24 by 29–30 μ; pedicel hyaline, short, 26–33 by 7 μ. Teleutosori small, black; teleutospore heads irregularly orbicular, chestnut-brown, 65–90 μ in diameter, appendaged; 4–5 spores in cross section, 18–20 by 25–30 μ, each with a long (8–12 by 5 μ) fulvous appendage which is branched at the apex; cysts hyaline, peripheral, pendent; pedicel compound, hyaline, short, deciduous.

On *Phyllanthus galeottinus:* Cuernavaca, Mexico, Sept. 15, 1899; also Guadalajara, Mexico, Oct. 12, 1896, *Holway*.

On *Phyllanthus* sp.: Ecuador, prov. Chimborazo, Puenti de Chimbo, Aug., 1891, *G. v. Lagerheim*.

RAVENELIA MEXICANA Transchel, Dietel in Hedwigia **33**: 370. 1894.—*Fig. 25.*

Sori breaking forth between the cuticle and the epidermal cells, scattered, on both sides of the leaves, very small, fulvous, surrounded by the ruptured cuticle. Uredospores intermixed with teleutospores (rare in specimens examined), ovate to spheroid, fulvous, echinulate; germ pores 4 (?), equatorial, walls thin, 18–20 by 23–25 μ; paraphyses in separate sori, clavate-capitate; heads light brown; pedicel hyaline, 18–20 by 40–55 μ. Teleutospore heads light brown, spinous, irregularly orbicular, 60–80 by 35 μ thick; spores 4–5 in cross section, each crowned with 2–4 blunt, curved hyaline spines, which range from mere warts to spines 8 μ long by 4 μ thick at base; cysts when dry, flat, and closely appressed to the under side of the heads, but in water swelling into an oblong shape and finally bursting, peripheral; pedicel weak, short, deciduous.

On *Calliandra grandiflora* Benth.: Mexico, State of Jalisco, mountains near Lake Chapale, Sept. 12, 1889, leg. *Pringle.*

The spines in this species are very variable in size and shape. Very few uredospores were present in the specimen examined, which was a part of the type collection kindly sent me by Dr. Dietel. For this reason, the number and position of the germ pores could not be determined with certainty.

Ravenelia leucaenae, n. sp.—*Fig. 23.*

Sori breaking forth between the cuticle and the epidermal cells, mainly on the upper side of the leaves, scattered very sparingly on the leaf stems. Uredosori cinnamon-brown, very small, from punctate to 0.4–0.6^{mm}, elliptical, surrounded by the ruptured cuticle; uredospores pale brown, base often semi-hyaline, with a darker but unthickened apex, oblong-linear to oblong-oval and sometimes oblong-ovate, usual shape oblong-linear, sparsely spinulose, 15–18 by 35–50 μ; germ pores 4, in the equator or between it and the base of the spore; paraphyses common, semi-hyaline, fulvous at apex, subclavate to sub-capitate, walls very thin, often collapsed, 18 by 40–50 μ. Teleutosori chestnut-brown, small, 0.4–0.6^{mm} in diameter, surrounded by the ruptured cuticle; teleutospore heads chestnut-brown, orbicular, 65–90 by 35–40 μ thick, papillate; 5–6 spores in cross-section, each spore crowned with several hyaline papillae 4–7 by 2–3 μ.; cysts oblong-ovate, flattened at base, peripheral, hyaline, swelling and finally bursting in water; pedicel short, hyaline, deciduous, apparently of separate hyphae..

On *Leucaena diversifolia:* Etla, Oaxaca, Mexico, Oct. 25, 1899, no. 3826, *Holway* (type).

On *Leucaena* sp.: Iguala, Mexico, Oct. 3, 1900, *Holway.*

This species is related to *R. goyazensis*, but differs from it in its shorter and hyaline papillae, in the shape of its cysts, and in the very small size of its sori. It differs from *R. Pazschkeana* Diet. in the unthickened apices of its uredospores and in the longer papillae, and in being subcuticular while *R. Pazschkeana* is sub-epidermal.

PLEORAVENELIA, n. gen.

Spermogonia formed between the cuticle and the epidermal cells, hemispherical. Aecidia with a well developed pseudoperidium. Uredospores borne singly on short stalks; germ pores few or many; paraphyses usually present in the uredosori. Teleutospores united into cushion-like heads formed of several or many cells; inner teleutospores two-celled by transverse or more or less oblique septa; outer spores one-celled; under side of teleutospore heads with several or many hyaline cells or cysts; pedicel of the head of several hyphae, which are either separate or united into a compound stipe.[1]

KEY TO SPECIES.

1.	Teleutospore heads smooth	2
	Teleutospore heads rough, warty, etc.	3
2.	Uredospore germ pores many (12–15), scattered; paraphyses many, clavate	*P. laevis*
	Uredospore germ pores 6–13, equatorial; paraphyses none	4
3.	Uredospore germ pores many, scattered; paraphyses many; teleutospore heads papillate	*P. indigoferae*
	Uredospore germ pores many, scattered; teleutospore heads warty and appendaged at base	*P. brongniartiae*
	Uredospore germ pores 4–6, equatorial; teleutospore heads minutely verrucose	*P. talpa*
4.	Germ pores 6. Uredospores fulvous, 25 by 34 μ	*P. epiphylla*
	Germ pores 8–12; uredospores brown, 20 by 25 μ	*P. similis*

Pleoravenelia laevis (Diet. and Holw.)—*Fig. 17.*

Ravenelia laevis Diet. and Holw., BOT. GAZ. **27**:35. 1897; Saccardo, Syll. Fung. **14**:366. 1899.

Sori subepidermal, on yellow spots on both sides of the leaves. Uredosori cinnamon color, few, small, surrounded by the ruptured epidermis; uredospores brown, oval to globose, spinulose, 21–26 by 22 μ; germ pores many (15 or more), scattered; paraphyses large, clavate, many, uniformly brown; heads 26–35 by 40 μ; stipe 40–65 by 10–12 μ, hyaline. Teleutosori black-brown, from punctate to 1^{mm} in diameter, abundant; teleutospore heads irregularly orbicular, dark brown, opaque, smooth, 85–120 μ in diameter; 5–6 spores in cross section; cysts cushion-shaped, connate with the pedicel, peripheral; pedicel compound, short, hyaline.

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[1] The other Ravenelias with the inner spores two-celled, which are not included in this paper, will also come under the new genus *Pleoravenelia*, and should be written **Pleoravenelia Hieronymi** (Speg), **P. MacOwaniana** (Pazschke), **P. glabra** (Kalchbr. and Cke.), and **P. tephrosiae** (Kalchbr.).

On *Indigofera densifolia:* Oaxaca, Mexico, Oct. 18, 1899, no. 3661, Holway.

On *Indigofera* sp.: Esclava, near City of Mexico, Oct. 3, 1896, Holway.

Differs from *P. epiphylla* and *P. similis* in having paraphyses, and in the numerous germ pores (15 or more).

Pleoravenelia similis, n. sp.—*Fig. 21.*

Sori subepidermal, on effused yellow spots, from punctate to 0.5^{mm} in diameter, on both sides of the leaves but especially abundant on the upper surface and more or less confluent over large areas. Uredosori few, ochraceous, small; uredospores brown, walls thick and dark brown, spinulose, oval to subglobose and often ovate, 20–28 by 17–23 μ; germ pores 8–12, irregularly scattered in or near the equatorial zone; paraphyses none. Teleutosori black-brown; teleutospore heads smooth, irregularly orbicular to oval, chestnut-brown, 68–135 μ, usual size 100 μ; 6–8 spores in cross section; cysts hyaline, peripheral and decurrent into the pedicel; pedicel hyaline, compound, short.

On *Brongniartia:* Guadalajara, Mexico, Sept. 14, 1899, no. 3145, *Holway* (type); also Oct. 1896, *Holway.*

The uredospores of this species blacken very much under continued boiling in lactic acid and glycerine solution, and shrink somewhat, while the uredospores of *P. epiphylla* do not blacken or shrink. It also differs from *P. epiphylla* in the number of germ pores, and in the brown uredospores.

Pleoravenelia epiphylla (Schw.).—*Fig. 18*

Sphaeria epiphylla Schw., Syn. Fung. Carol no. 130 p. 40. 1822; Saccardo, Syll. Fung. **2**: 399. 1883; Farlow, Host Index 30. 1888; Ellis and Everhart, N. A. Pyren. 745. 1892.

Ravenelia glanduliformis Berk. and Curt., Cooke in Jour. Roy. Micr. Soc. 3:385. 1880; Grevillea 3:56. 1874; Parker, Proc. Amer. Acad. **21**:205–

217. 1886; Atkinson, Some fungi from Alabama, Bull. Cornell Univ. Science 3 : 20. 1897.

Ravenelia epiphylla Dietel, Hedwigia 3 : 27–29, 59. 1894.

Sori subepidermal, on both sides of the leaves and on the leaf stems and branches, scattered, crowded or confluent. Uredosori small, ochraceous, surrounded by the ruptured epidermis, scattered, usually confined to the leaves; uredospores fulvous to semi-hyaline, walls thin, broadly oval to broadly ovate, verrucose, 30–40 by 23–26 μ, usual size 34 by 25 μ; germ pores 6, in the equator; paraphyses none. Teleutosori on both stems and leaves, scattered or confluent, black-brown; teleutospore heads chestnut-brown, very variable as to size and shape, smooth, 80–115 by 33–45 μ thick; 4–7 spores in cross section; cysts hyaline, decurrent into the pedicel; pedicel short, hyaline.

On *Tephrosia virginiana:* South Carolina, 1876, *Ravenel*, no. 1251, Thümen Myc. Univ. Fungi Car.; Rav. Fung. Car. no. 72; White Sulphur Springs, West Va., no. 705, *M. B. Waite;* Oregon, Ill., Sept. 3, 1886, no. 84, *M. B. Waite;* Munith, Mich., 1893, *G. A. Hicks*, no. 1787, Plants of Mich.

On *Tephrosia* sp.: South Carolina, *Aiken*, no. 55, Rav. Fung. Am. Exsic.

On *Tephrosia hispidula:* Auburn, Alabama, Sept. 9, 1893, *Duggar;* Auburn, Ala., Sept.–Oct. 1891, *Duggar* and *Atkinson;* Oct. 11, 1891, no. 2208, *Atkinson;* Center, N. Y., *Peck*, no. 363, Ell. N. A. Fung.

On *Tephrosia spicata:* Lake City, Florida, Oct. 16, 1899, no. 17, Fungi of Fla., *H. H. Hume;* Auburn, Alabama, no. 2146, *Atkinson.*

In all specimens of this species examined the uredospores were typical of the species and distinctly different from the uredospores of *P. similis* on Brongniartia.

Pleoravenelia indigoferae (Transz.).—*Fig. 19.*

Ravenelia indigoferae Transz., Dietel in Hedwigia 33 : 369, 1894; Saccardo, Syll. Fung. 11 : 211. 1895.

Sori subepidermal, on both sides of the leaves and on the leaf stems and branches. Uredosori sparse in material examined, pale yellow, small; uredospores oval to globose, 20–23 by 23–27 μ, epispore with sparse short prickles, light yellow; germ pores many, scattered; paraphyses many, clavate to subcapitate, brownish, walls of heads dark brown, contents faintly brown, 20–25 μ; stipe hyaline, 50–80 by 7 μ. Teleutosori black, small, scattered on the leaves; on the stems and branches confluent and causing large swollen places of several centimeters in extent; teleutospore heads irregularly orbicular, chestnut-brown, 80–125 μ broad, beset with pale brown papillae (3 by 4–6 μ); 4–6 spores in cross section, each spore crowned with several (4–8) papillae.

On *Indigofera cuernavacana* Rose: Cuernavaca, Mexico, Sept. 28, 1898, no. 3120, *Holway*.

On *Indigofera Palmeri* Wats.: Oaxaca, Mexico, Oct. 19, 1899, no. 3682, *Holway*.

Pleoravenelia brongniartiae (Diet. and Holw.)—*Fig. 20.*

Ravenelia brongniartiae Diet. and Holw., BOT. GAZ. **35**: 1897; Saccardo, Syll. Fung. **14**: 368. 1899,

Sori breaking forth from beneath the epidermis. Uredosori single or clustered, on both sides of the leaves, cinnamon-brown, spots large, yellow, about 5^{mm} in diameter; uredospores ovate to globose, 23–30 by 18–25 μ, spinulose; germ pores many, scattered; paraphyses none. Teleutosori not on spots, black; teleutospore heads orbicular, 85–115 μ in diameter, chestnut-brown, entire surface densely covered with large warts, while each marginal spore has one large dark brown blunt process; 5–6 spores in cross section, spores 16–21 μ long; cysts united into a coniform body which is decurrent into the pedicel; pedicel compound, short, hyaline.

On *Brongniartia* sp.: Cuernavaca, Mexico, Sept. 29, 1899. no. 3591, *Holway;* Sept. 28, 1898, no. 3022 and no. 3170, Sept. 23, 1896.

On *Brongniartia sericea:* Oct. 18, 1899, no. 3663, *Holway*.

On *Brongniartia intermedia:* Tizapan, near City of Mexico, Sept. 27, 1899, no. 3504½, *Holway*.

All from Herb. E. W. D. Holway.

Pleoravenelia talpa, n. sp.—*Fig 22.*

Sori subepidermal, thickly distributed over both sides of the leaves. Uredosori few, ochraceous, surrounded by the ruptured epidermis, small; uredospores brown, walls thick, verrucose, ovate to subglobose, usually inequilateral, 25–32 by 18–22 μ, usual size 30 by 20 μ; germ pores equatorial, 4–6, not easily visible even after boiling in lactic acid; paraphyses none. Telutosori small, black-brown, many, surrounded by the ruptured epidermis; teleutospore heads dark brown, irregularly orbicular to oval, minutely but distinctly verrucose, 65–115 by 35–40μ thick, usual size 85μ; 4–8 spores in cross section, each spore crowned with several small scattered semi-hyaline warts, which are not arranged along the margins of the spores; cysts hyaline, peripheral, decurrent into the pedicel, swelling and bursting in water; pedicel compound, short, hyaline.

On *Tephrosia talpa* Wats.: Oaxaca, Mexico, Oct. 19, 1899, no. 3679, *Holway*.

This differs from *R. epiphylla* in its warty head, smaller and browner uredospores; and from *R. tephrosiae* in the very small warts of its teleutospores and in its larger uredospores, as a careful comparison with type specimens showed.

NEORAVENELIA, n. gen.

Spermogonia breaking forth between the cuticle and the epidermal cells, hemispherical. Aecidia without a pseudoperidium, borne caeoma-wise. Uredospores borne singly on short stalks; germ pores few or many; paraphyses usually present in the uredosori. Teleutospores united into cushion-like heads, formed of several or many spores; all the spores of the entire head one-celled; under surface of teleutospore heads with several or many hyaline cells or cysts; pedicel of the head of several hyphae, which are either separate or united into a compound stipe.

Neoravenelia Holwayi (Diet.).—*Fig. 24.*

Ravenelia Holwayi Diet., Hedwigia 33:52–53, 61. 1894; Saccardo, Syll. Fung. 11:216. 1895.

Aecidial stage forming galls and cap-shaped excrescences on the leaves and leaf stems; galls oblong to globose, more or less curled and distorted, very variable in size, 1–4$^{\mathrm{cm}}$ long by 2–6$^{\mathrm{mm}}$ thick; "caps" on the leaflets 1–2$^{\mathrm{mm}}$ tall by 3–5$^{\mathrm{mm}}$ broad, with the concavity on the lower side of the leaflet; spermogonia on both sides of the "cap," subcuticular, preceding and with the aecidiospores, dark brown, 46–60 μ in diameter.

I. Aecidiosori deep seated, mummy-brown when fresh, ochraceous when desiccated, oblong to oval, 1–3$^{\mathrm{mm}}$ long by 1$^{\mathrm{mm}}$ broad, finally becoming more or less confluent over the entire surface of the galls, opening by a median longitudinal slit; sori usually concentrically disposed on the convex and upper surface of the "caps;" pseudoperidium none; aecidiospores in chains, caeoma-wise, spores linear-oblong to subovate, very irregular in shape and size and often angular or prolonged into a point at one or both ends; walls thick, densely granular, light brown, 13–20 by 30–40 μ; germ pores 4, equatorial, faint.

Uredo- and teleutosori subepidermal, on both sides of the leaves and sparingly on the leaf stems.

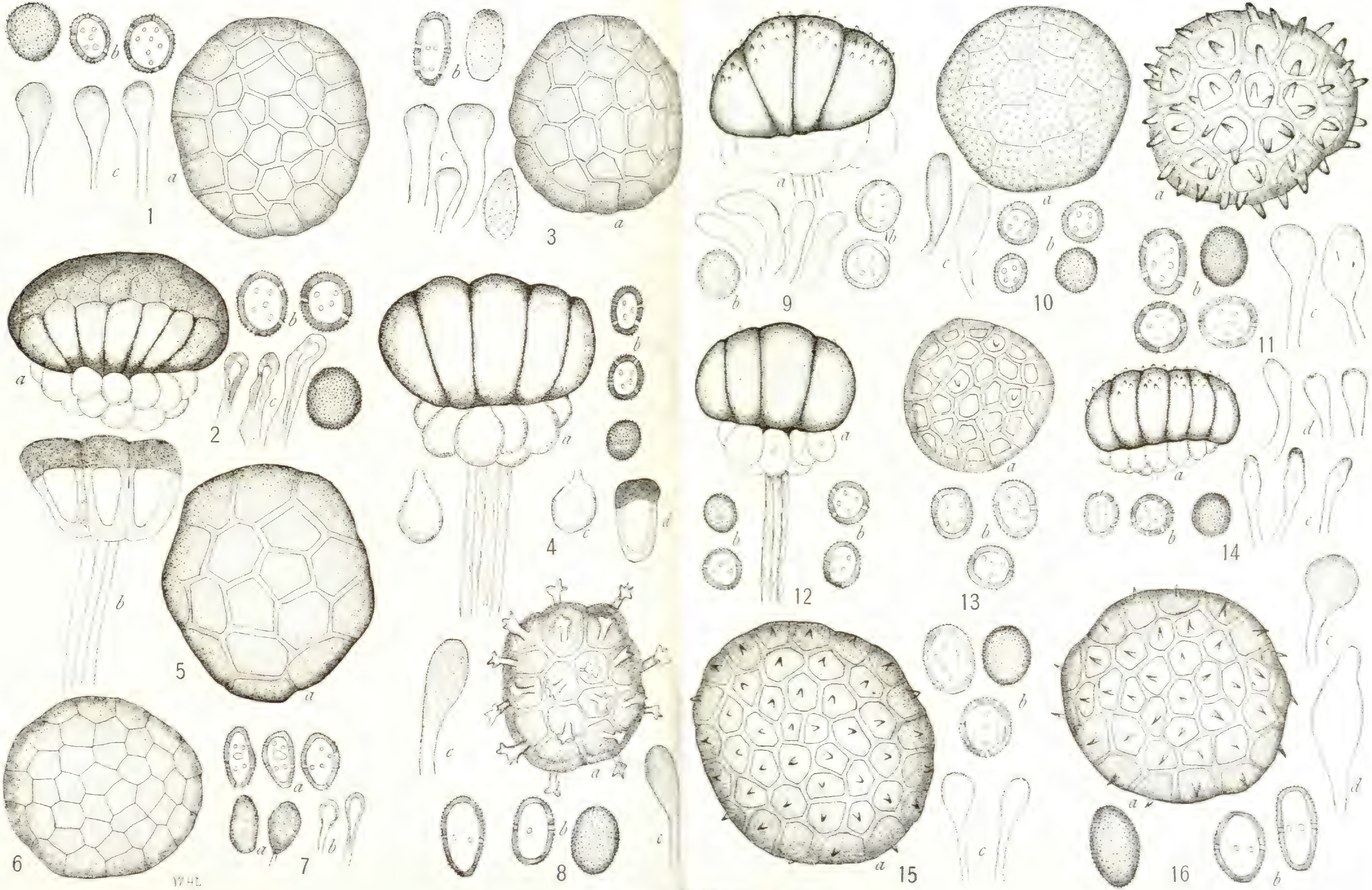
II. Uredosori orbicular to elliptical, averaging 0.3–0.5^{mm}, sometimes 0.6–0.7^{mm} in diameter, cinnamon-brown, or chestnut-brown when many paraphyses are present; uredospores oval to obovate to fusiform, 17–24 by 32–45 μ, fulvous, darker and thickened somewhat at the apex, spinulose; germ pores four, equatorial; paraphyses many, capitate; heads intensely dark brown, 15–20 by 20–25 μ; pedicels stout, hyaline to fulvous, 5 by 20–35 μ.

III. Teleutosori black, scattered, large, 0.75–1–2^{mm} in diameter; teleutospore heads intensely dark brown, opaque, apex depressed, smooth, 100–150 μ in diameter; 6–10 spores in cross section, each spore 15–20 by 40–45 μ, apex intensely brown for 12–14 μ, remainder of spore semi-hyaline; cysts hyaline, many, beneath the entire head, pendent, ovate to spheroid, swelling and bursting in water; pedicel hyaline, compound, or of separate hyphae, short, deciduous.

On *Prosopis juliflora*: Austin, Texas, May 8, 1901, no. 909 (type of aecidial stage); Aug. 26, 1901, no. 1031 (type for II and III); July 2, 1900, no. 25; Oct. 25, 1900, no. 10; Denton, Texas, June 12, 1902 (I), and Oct. 20, 1902 (III); College Station, Texas, July–Aug. (II), 1888, leg. *Pammel*; Texarkana, Texas, Nov. 5, 1899 (III), *Holway*; San Bernardino, Cal.; leg. *S. B. Parish*, no. 2541 (type of *R. Holwayi* Diet.).

The galls appear soon after the leaves are expanded. In about two weeks the aecidiosori began to open; the galls persist on the trees for several weeks and then usually fall off. They are followed in about two weeks by the uredosori which do not form galls. The uredospore stage continues till October, when the teleutospores begin to appear and these continue till frost kills the leaves of the host.

The rust usually infests trees that are in a low, damp situation, as on the margin of a stream or in a ravine. The "caps" usually appear before the galls and seem to be confined to the leaflets, while the galls are on the leaf stems and young branches.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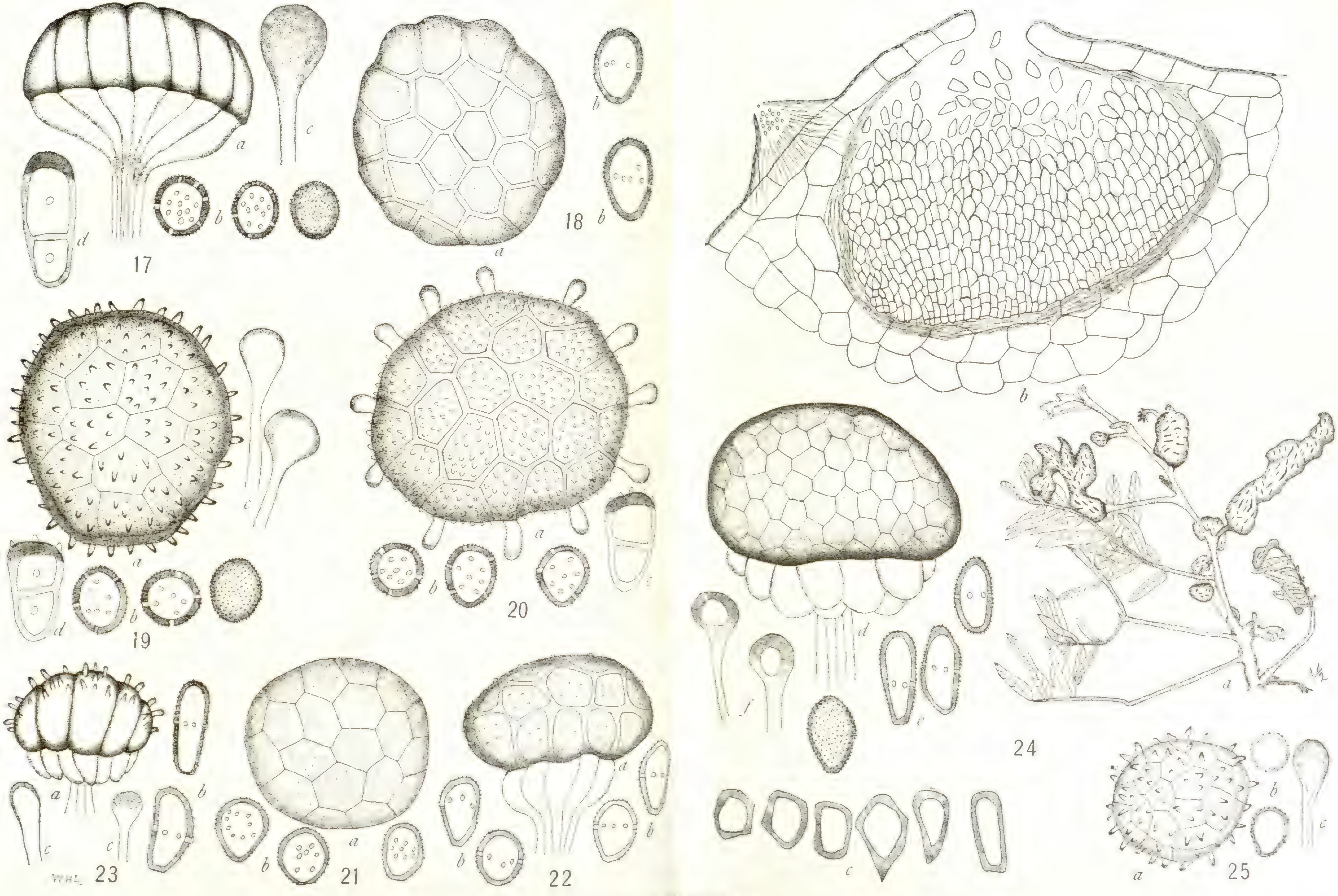
LONG on RAVENELIA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LONG on RAVENELIA

All three stages have been repeatedly found by the writer on the same trees, the aecidial stage first and the other stages appearing in due time. Occasionally an old dead gall will continue on the trees till the next spring. The descriptions were all drawn from material collected at Austin, Texas.

There is some doubt in the writer's mind about this species being identical with the old *Ravenelia Holwayi*, as there are several minor differences, but none apparently of sufficient value to separate it from *R. Holwayi* Diet. The aecidial stage being of the caeoma type throws it into a new genus.

DENTON, TEXAS.

EXPLANATION OF PLATES II AND III.

All figures except *24a* and *24b* are magnified, after reduction, 400 times; *24a*, as indicated on plate and *24b* are magnified 80 times.

FIG. 1. *Ravenelia texana: a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 2. *Ravenelia Longiana: a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 3. *Ravenelia versatilis: a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 4. *Ravenelia indica: a*, teleutospore head; *b*, uredospores; *c*, cysts; *d*, simple teleutospore.

FIG. 5. *Ravenelia opaca: a*, teleutospore head; *b*, three teleutospores and pedicel.

FIG. 6. *Ravenelia Farlowiana:* teleutospore head.

FIG. 7. *Ravenelia siliquae: a*, uredospores; *b*, paraphyses.

FIG. 8. *Ravenelia appendiculata: a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 9. *Ravenelia verrucosa: a*, teleutospore head; *b*, uredospores; *c*, paraphyses,

FIG. 10. *Ravenelia expansa: a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 11. *Ravenelia mimosae-sensitivae: a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 12. *Ravenelia cassiaecola: a*, teleutospore head; *b*, uredospores.

FIG. 13. *Ravenelia mesillana: a*, teleutospore head; *b*, uredospores.

FIG. 14. *Ravenelia fragrans: a*, teleutospore head; *b*, uredospores; *c*, common or typical paraphyses; *d*, uncommon forms of paraphyses.

FIG. 15. *Ravenelia spinuiosa: a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 16. *Ravenelia arizonica: a*, teleutospore head; *b*, uredospores; *c*, typical form of paraphyses; *d*, cystoid paraphysis.

FIG. 17. *Pleoravenelia laevis: a*, teleutospore head; *b*, uredospores; *c*, paraphyses; *d*, teleutospore.

FIG. 18. *Pleoravenelia epiphylla: a*, teleutospore head; *b*, uredospores; *c*, paraphyses; *d*, teleutospore.

FIG. 20. *Pleoravenelia brogniartiae: a*, teleutospore head; *b*, uredospores; *c*, teleutospore.

FIG. 21. *Pleoravenelia similis: a*, teleutospore head; *b*, uredospores.

FIG. 22. *Pleoravenelia talpa: a*, teleutospore head; *b*, uredospores.

FIG. 23. *Ravenelia leucaenae: a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

FIG. 24. *Neoravenelia Holwayi: a*, galls with aecidiosori on them; *b*, an aecidiosorus and one spermogonium; *c*, aecidiospores; *d*. teleutospore head; *e*, uredospores; *f*, paraphyses.

FIG. 25. *Ravenelia mexicana: a*, teleutospore head; *b*, uredospores; *c*, paraphyses.

BRIEFER ARTICLES.

CHALAZOGAMY IN CARYA OLIVAEFORMIS.

Nawaschin[1] announced in 1895 that the pollen tube in *Juglans regia* does not enter the micropyle, but passes down the ovary wall and enters the ovule through the chalaza. It was not surprising, therefore, when in examining some longitudinal sections of pecan fruits I found the chalazal region of the ovules penetrated by pollen tubes. The material was gathered in the spring of 1902, a few days after the withering of the anthers. Though insufficient in amount for embryological work, for which the specimens were primarily collected, they show undoubted evidence of chalazogamy.

The general morphological character of the ovary wall and ovule resembles that of Juglans as described by Nawaschin. The placenta nearly fills the lower part of the ovary cavity on two opposite sides, and actually fuses with the ovary wall on the two sides lying in a plane at right angles to the first two. These two regions of fusion, lying on opposite sides of the placenta, correspond to the "flügelartige Wucherungen" of Juglans, and form, as do the "Wucherungen," the tissue through which the pollen tube travels to reach the base of the ovule. The single integument tightly encloses the orthotropous ovule. A micropylar canal is present, but is bent near its upper end, thus bringing its aperture into a lateral rather than apical position. No pollen tubes were found entering the canal.

The course of the fibrovascular bundles from the ovary wall to the ovule is not through the length of the placenta, but transversely through its upper part to a region immediately under the funiculus, at which point they turn abruptly upwards and pass through the chalaza into the integument. Two bundles enter in this manner from either side through the region of fusion, and then curve so as to approach each other under the funiculus in a plane approximately at right angles to that of the two regions of fusion. Such an arrangement leaves the coast clear for the direct passage of the pollen tube from the ovary wall to the funiculus.

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[1] Nawaschin, S., Ein neues Beispiel der Chalazogamie. Bot. Centralbl. **63**: 353–357. 1895.

The so-called conducting tissue of the style consists of cells elongated in the direction of the long axis of the ovary, and differs in no material respect from that ordinarily seen. The pollen tube passes down the axial tissue of the style till near the cavity of the ovary, where it turns and passes down the ovary wall close to the margin of the cavity. The tissue through which it passes after leaving the style has nothing by which it could be designated "conducting tissue," but consists of nearly isodiametric cells. When a point is reached a little below the funiculus, the pollen tube curves, passes through a region of deeply-stained cells (as though mucilaginous), and when under the ovule turns upward towards the embryo sac.

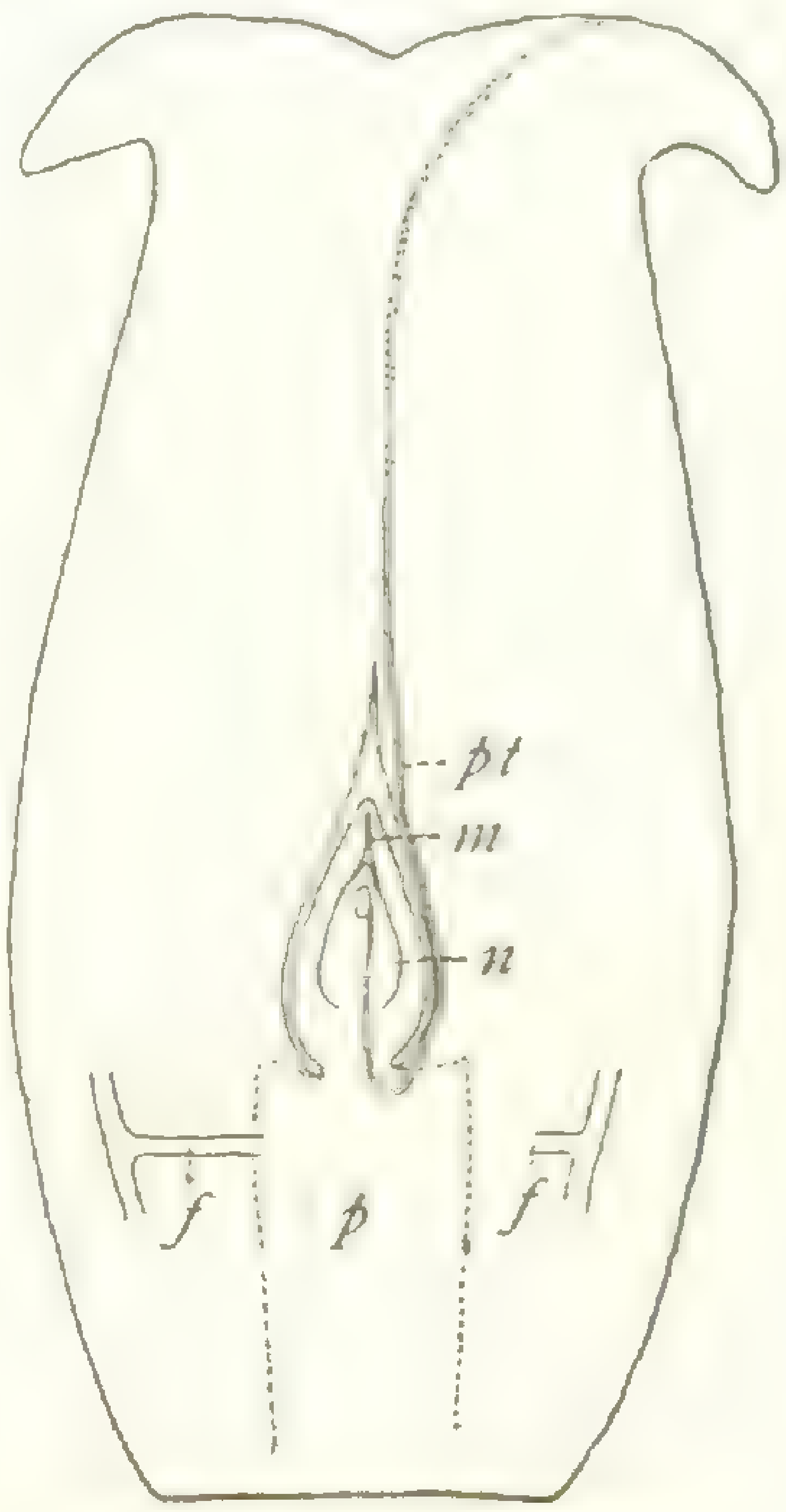

Diagram illustrating chalazogamy in the pecan: *p*, placenta, cut in the plane of fusion with the ovary wall; the approximate lines of fusion are represented by dotted lines; *f*, fibrovascular bundles running to the ovule; *n*, nucellus; *m*, micropylar canal; *pt*, pollen tube.

While the course of the tube is not difficult to see in the ovary wall, it is particularly conspicuous as it passes through the parenchymatous cells of the chalaza and nucellus. The account of the course taken by the pollen tube, as described above, is essentially that given by Nawaschin for Juglans. The branching of the tube recorded by Nawaschin appears to have its counterpart in the pecan. Although I have not settled this point by a number of observations, yet I did see a distinct branching in one case, and nearly every ovule examined showed the presence of more than one tube in the nucellus. If branching occurs, it takes place after the pollen tube has entered the subfunicular tissue.

Nothing definite has been made out as to the process of fertilization, or the nature of the embryo sac, but it is hoped that additional material will reveal something of interest along these lines.—FREDERICK H. BILLINGS, *Louisiana State University.*

SELECTED NOTES.

LEAF VARIATION IN *Liriodendron Tulipifera.*—A recent article by E. M. Berry on the phylogeny of Liriodendron (BOT. GAZ. **34**: 44–63. 1902) attracted my attention to the subject of leaf variation in this genus. The subject was mentioned to the students, and in a few days Mr. Ivey Lewis found a tulip tree with very variable leaves, from which we collected a number of forms. The tree was a fairly vigorous one, about eighteen feet high, growing on the edge of an open field. *Fig. 1* is from a photograph of six selected leaves from this tree. The type of variation represented by the two pointed leaves shown is of very rare occurrence in the living species, and apparently so far has been described by Berry only (Torreya 2:33. 1902). As the leaves of Liriodendron are usually considered remarkably constant to type, it was thought that a photograph of such widely different forms produced on the same tree might be of interest.

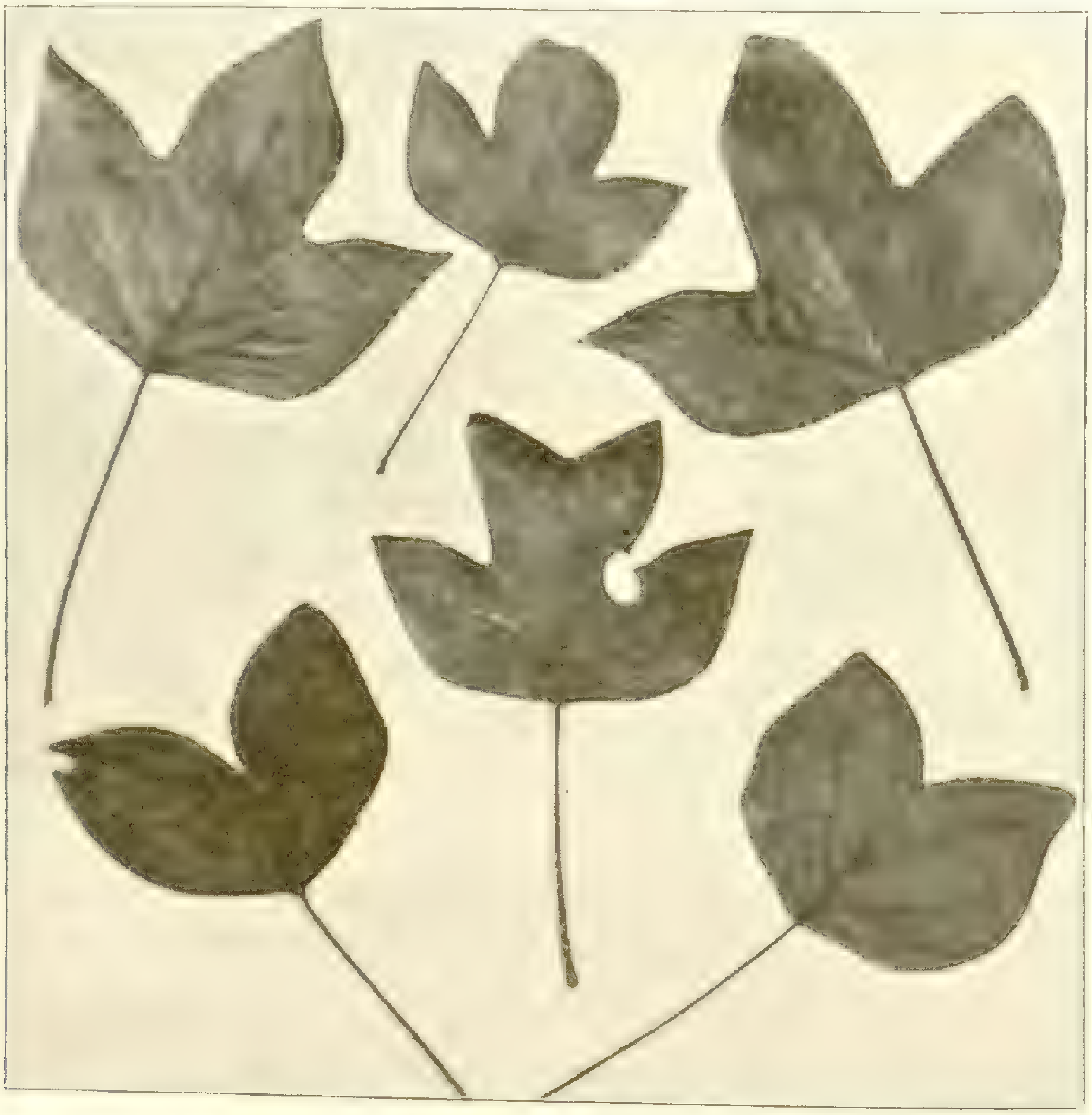

FIG. 1.—Photograph of six leaves from a single tree of *Liriodendron Tulipifera*. The tip of one leaf that was broken off after drying has been inserted in the photograph.

ON THE OCCURRENCE OF TWO EGG CELLS IN THE ARCHEGONIUM OF MNIUM.—While sectioning the female "flowers" of an undetermined species of Mnium, collected near Baltimore in the spring of

1900, an archegonium was found which contained two well-developed egg cells of perfectly normal appearance. The supernumerary one lay directly over the other, being inserted as a link in the axial row of cells present. *Fig. 2* represents their arrangement. Each egg has cut off its ventral canal cell above and is apparently ready for fertilization. One neck canal cell (*nc*) is shown. It seems probable that the upper egg cell has been derived from the lower neck canal cell by an abnormal modification of the latter. This is the only case, as far as I know, where two eggs have been observed in the archegonium of any of the archegoniates.

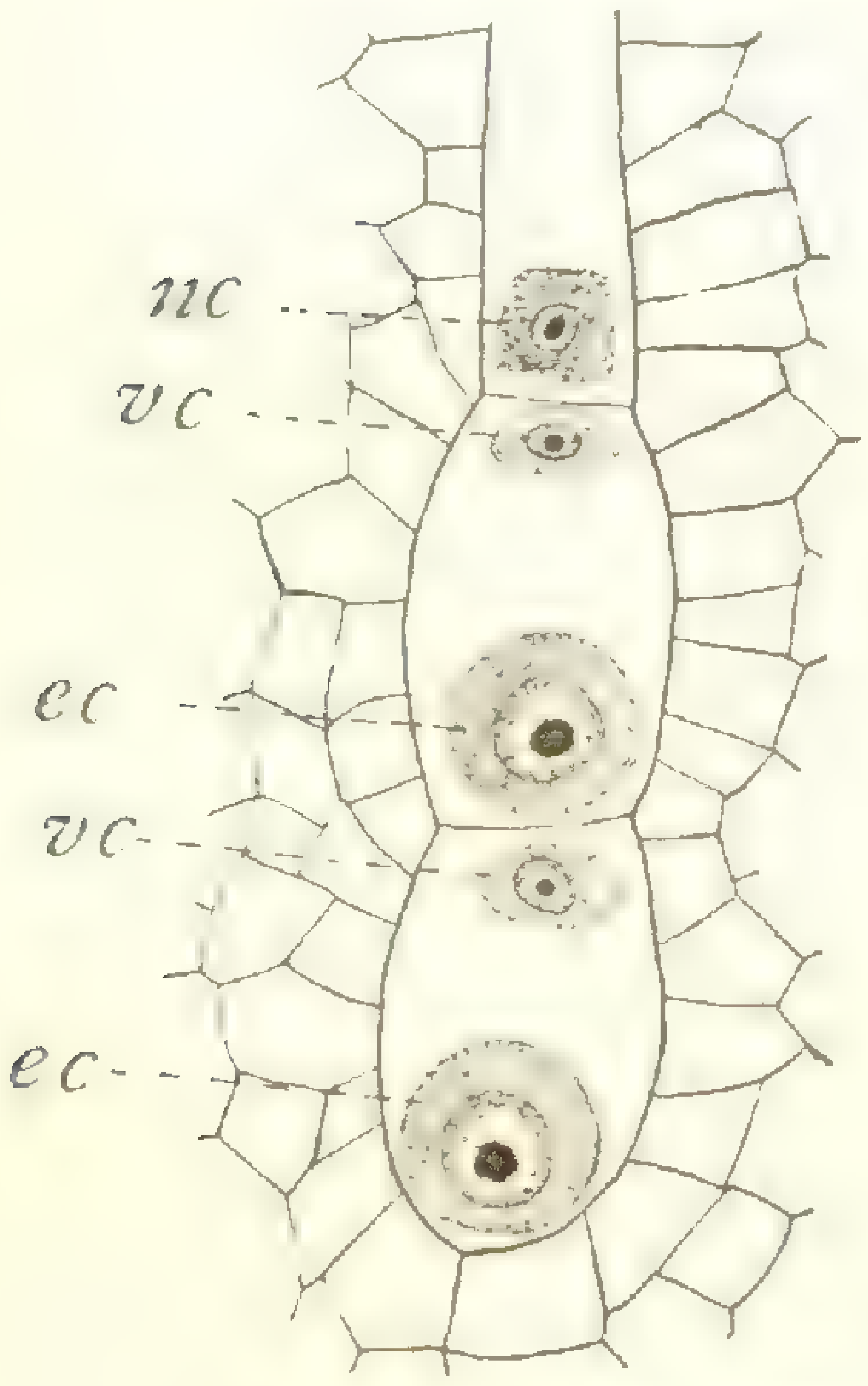

FIG. 2.—Part of venter of archegonium of Mnium, with two eggs and two ventral canal cells: *ec*, egg cell; *nc*, neck canal cell; *vc*, ventral canal cell. × 1050.

THE NUCLEUS OF THE SPORE CAVITY IN PROTHALLIA OF MARSILIA.—The nucleus left with the food material in the cavity of the megaspore on the formation of the prothallium seems to have been much neglected. Campbell (*Mosses and Ferns*, p. 404) figures this nucleus apparently disorganizing in *Marsilia vestita*, and speaking of Azolla says (*ibid.*, p. 384) "the nucleus of the lower cell remains in the upper part, and is much like that of the prothallial cell." With these exceptions this nucleus seems to have received little attention. While studying the prothallium of *Marsilia Drummondii*, notes were made on

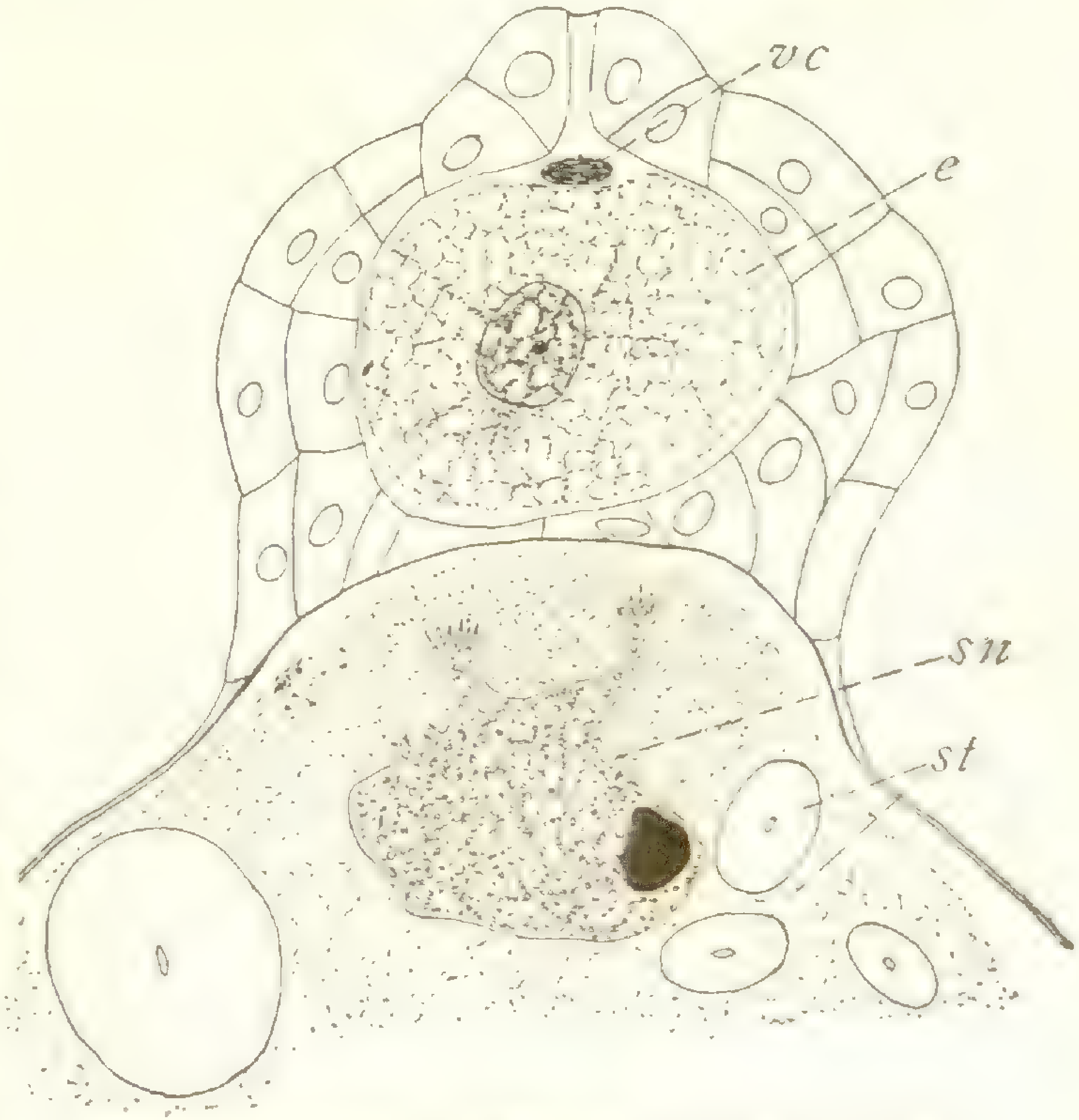

FIG. 3.—*Marsilia Drummondii*, showing upper part of megaspore with archegonium: *vc*, ventral canal cell; *e*, egg; *sn*, large nucleus in megaspore cavity; *st*, starch grains. × 670.

the intersporic nucleus which may be worth recording. The nucleus enlarges greatly as development proceeds, retains its position at the tip of the spore cavity, and at the time of fertilization is vastly larger than the nuclei of the remaining tissue, as shown in *fig. 3*. In this figure the peculiar shape of the nucleus attracts attention. Two long arms are projecting towards the prothallium, and other filaments extend upward from one side. The shape of the nucleus is not at all constant, but at this stage it is generally furnished with fine extensions radiating towards the prothallium. *Fig. 4* shows the nucleus of another spore at the same stage. As development proceeds, the nucleus fragments amitotically into a number of parts. *Fig. 5* represents two such fragments, one on each side, after the embryo has begun to develop. In *fig. 6* fragmentation has proceeded still further. The reticulum is throughout very dense and homogeneous and a nucleolus is present. It is hardly probable that the peculiar processes figured can be an artifact, as all other parts seem very well fixed. If these processes are normal, as seems probable, they recall the filaments extending from the nucleus into the food mass in the egg cell of Dytiscus (Wilson, *The Cell*, p. 115). In the case of Marsilia, however, the processes extend towards the tissue to be nourished, instead of towards the food material. The nucleus is here, doubtless, quite active in the elaboration or transference of food material, and it is not surprising that it should show special modification to this end. The final fragmentation reminds one of similar behavior of the nuclei in purely vegetable cells of Chara, Tradescantia, and many other plants.—W. C. Coker, *University of North Carolina, Chapel Hill.*

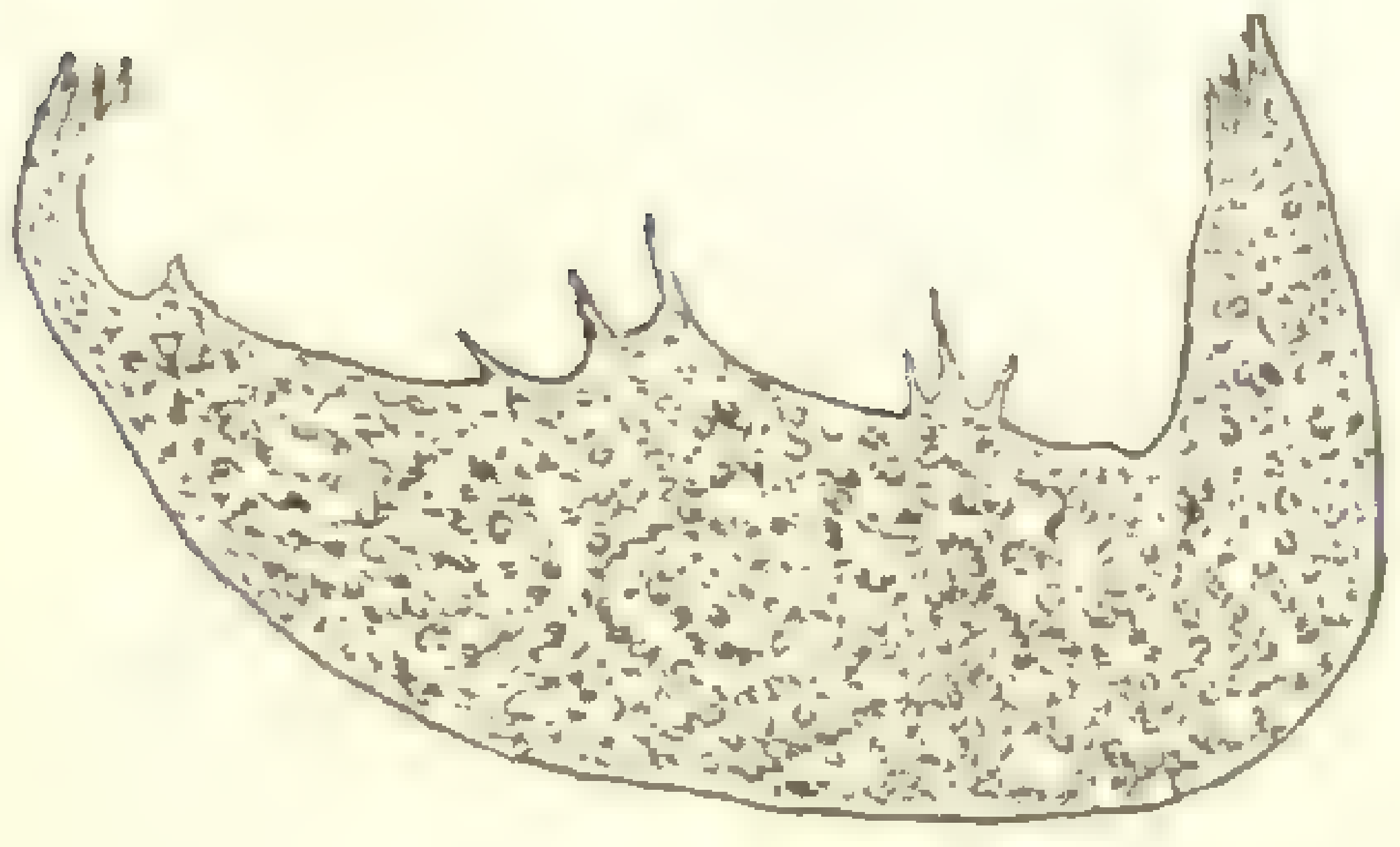
FIG. 4.

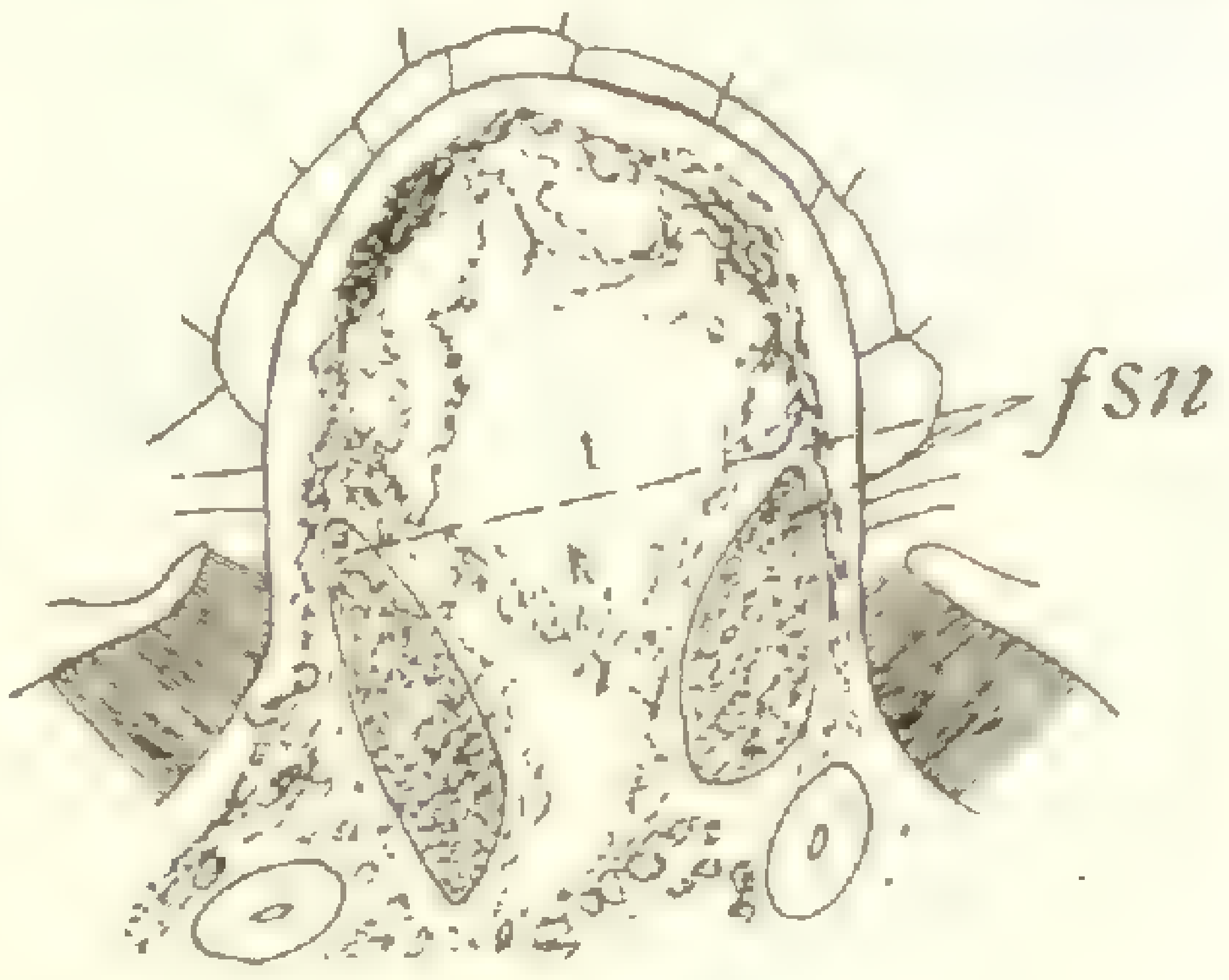

FIG. 5.

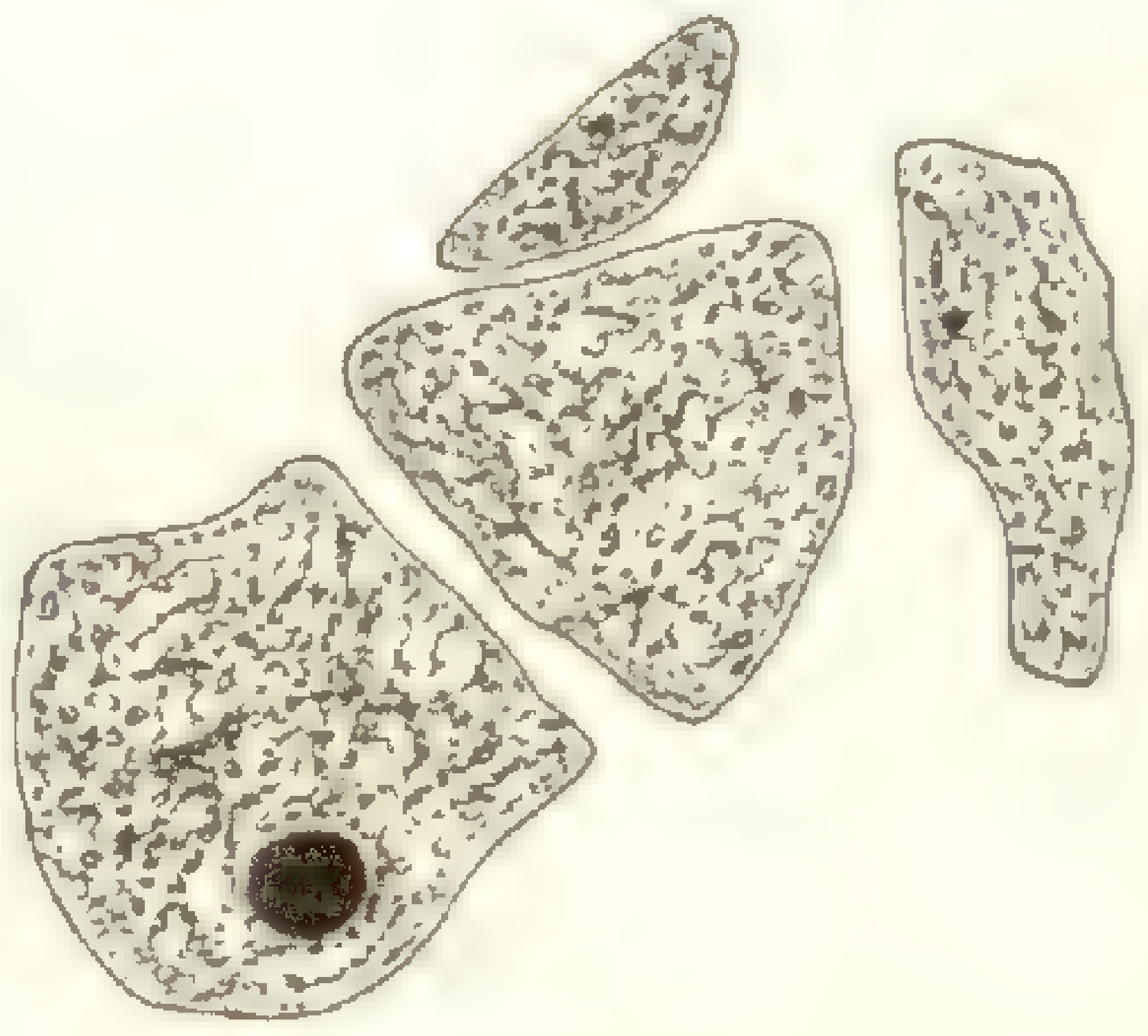
FIG. 6.

FIG. 4.—The same as *fig. 3*, showing nucleus of spore cavity. × 1050.

FIG. 5.—The same as *fig. 3*, showing papilla of spore cavity with two fragments of the nucleus (*fsn*); later stage than above. × 370.

FIG. 6.—The same as *fig. 3*, showing fragmentation carried still further. × 1050.

CURRENT LITERATURE.

BOOK REVIEWS.

Dune work in Germany.

IN THIS BOOK Gerhardt[1] presents a very comprehensive account of the historical development, as well as the present status, of dune control in the classic dune areas along the shores of the Baltic and North seas. He has been ably assisted in the geological, floristic, and sylvicultural aspects of the work by Jentzsch, Abromeit, and Bock, respectively. The sources of the sand, the factors at work, and the laws governing the movement and contour of the dunes are considered in some detail, as are also the ecological adaptations of the various species of dune plants. Historical records indicate that as early as 1738 the problem of controlling the shifting sand had been solved for certain areas; but the development of modern methods and organized work dates from about the beginning of the last century, when Biörn demonstrated that a certain combination of hedges, grass-plats, etc., is effective in checking the advance of a wandering dune. Krause and Hagen furthered the work of Biörn, both in the extension of the areas protected and in the improvement of methods. Near the town of Narmeln, situated on the Frischen Nehrung, occurs an example of their work. Two rapidly advancing dunes had already encroached upon the town limits when Krause began his work, which was prosecuted with such success that the threatening dunes were under complete control before serious damage was done, and although over half a century has passed, the town has never since been seriously threatened with a further advance of the dunes.

Excellent illustrations and diagrams aid in the clear exposition of the various devices with which the newly transplanted vegetation is protected, and the shifting sand captured and held. Directions for culture and detailed descriptions of the various grasses, shrubs, and trees recommended are given, together with a statement of the steps necessary to the final forestation of the wandering dune. The existing farms, with their gardens and orchards, where a hundred years ago were only sand wastes, and the wooded elevations that mark the site of once wandering dunes bear witness to the effectiveness of the methods used in these areas. And there appears no reason why these methods may not be successfully applied wherever the shifting sand endangers valuable property.—J. M. WESTGATE.

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[1] GERHARDT, PAUL, Handbuch des deutschen Dünenbaues, pp. xxviii + 656 *figs. 445*. Berlin: Paul Parey. 1900.

French forests.

A VERY CAREFUL and thorough discussion of the forests of France has come from MM. Boppe and Joylet of the national school of forestry at Nancy.[2] The work begins with a discussion of the form and reproduction of a tree as influenced by its environment, followed by descriptions of the principal native species, in which the habitat, distribution, and forest value of each are given. Then follows a detailed treatment of the forest-stand, the influence of its trees upon the soil and upon each other. An aggregation of stands makes a forest. As concerns forests, the climate of France falls into two great divisions: (1) that of the plains, subdivided into three zones according to the distribution of the rainfall and the resultant forest growth; and (2) that of the mountains, the climate of each mountain system being treated separately.

The greater part of the book is devoted to a detailed discussion of the methods and principles of sylviculture as employed in France. Of special economic interest is the account of the reforestation of denuded mountain slopes and of the fixation of sand dunes.

In the treatment of the forests in their biological and sylvicultural relations this book covers the ground more thoroughly than any American treatise on a similar subject.—C. D. HOWE.

MINOR NOTICES.

ALICE R. NORTHROP[3] has published an account of the flora of two of the Bahama islands, with an enumeration of the plants collected by John I. Northrop and herself in 1890, a collection including 542 species. After some description of the general ecological features of the region, the list of plants is given. Several new species from the collection had previously been described by various authors, and the present publication contains additional new species, and also two new genera of palms (*Paurotis* and *Cyclospathe*), described by O. F. Cook. Following the list is a study of the relations of the Bahama flora, as illustrated by the collection of the author. Of the 453 native vascular plants found on New Providence and Andros, 176 are reported from other islands of the group, 335 from Cuba, 250 from southern Florida, 108 from southern United States, 286 from Jamaica, 190 from Virgin islands, 223 from Windward islands, 196 from Mexico and Central Mexico, and 199 from South America.—J. M. C.

NOTES FOR STUDENTS.

HUNGER[4] has studied the granules which occur in the thallus of Dictyota. He finds that the smaller ones near the plastids are of a monosaccharid nature. The larger granules in the interior of the cells are composed largely of polysaccharid and contain considerable tannin.—BURTON E. LIVINGSTON.

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[2] BOPPE, L., and JOYLET, ANT., Les forêts, traité pratique de sylviculture, pp. xi + 488. 95 photogravures. Paris: J. B. Baillière & fils. 1901.

[3] NORTHROP, ALICE R., Flora of New Providence and Andros (Bahama islands). Mem. Torr. Bot. Club **12**: 1–98. *pls. 1–19.* 1902.

[4] HUNGER, F. W. T., Ueber das Assimilations-Product der Dictyotaceen. Jahrb. Wiss. Bot. **38**: 70–82. 1902.

T. J. and M. F. L. FITZPATRICK[5] give a short account of the genetic development of the island vegetation of the Mississippi river near Sabula, Iowa. The characteristic species associated with the willow-cottonwood-elm society are listed and the significance of certain tendencies indicated.—J. M. WESTGATE.

HUŠEK[6] finds the grains in the root-cap of *Allium Cepa* to be the so-called "red starch;" beside amylodextrin they contain a little real starch and some dextrin. The red starch is formed only at ordinary temperatures. The amyloplasts are confined to the root-cap. If the tip is removed, they occur in the regenerated tip. They are formed there *de novo* from the cytoplasm in Allium.—E. B. COPELAND.

GUIGNARD[7] has just reported double fertilization among the Cruciferae. The forms studied were *Capsella Bursa-pastoris* and *Lepidium sativum*, which prove to be almost identical in their main features. The polar nuclei fuse late, just before the entrance of the tube, the fusion-nucleus lying very close to the oosphere. The male cells are small and ovoid, and after discharge from the tube pass so rapidly to the oosphere and the fusion-nucleus as not to be caught in the preparations during their passage. The fusion of the male cell with the endosperm nucleus is very much more rapid than the fusion of its mate with the egg. It seems to be more and more evident that the so-called double fertilization is a very general phenomenon among angiosperms.—J. M. C.

BREUNER[8] has made an ecological study of the oak leaves of the world, as to their general adaptations to their native climates. His work includes a study of cultivated or herbarium material from all lands where oaks grow, and some experiments upon living material to show the influence of illumination upon the size, form, and structure of the leaves. Except for the excessive individual variability of oak leaves, the genus is a most favorable one for such work. The results of experiments, and of local differences in environment correspond to the specific characters in the climates imitated; whence Breuner concludes "that the modifications in plants called forth by external causes become hereditable, and in the course of evolution may develop into specific characters."—E. B. COPELAND.

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[5] FITZPATRICK, T. J. and M. F. L., A study of the island flora of the Mississippi river near Sabula, Iowa. Plant World 5: 198–201. 1902.

[6] HUŠEK, G., Ueber Stärkekörner in den Wurzelhauben von *Allium Cepa.* Reprint, Sitzber. K. Böhm. Gesells. Wissens. 1902. 10 pp.

[7] GUIGNARD, L., La double fécondation chez les Crucifères. Jour. Botanique 16: 361–368. *figs. 20.* 1902.

[8] BREUNER W., Klima und Blatt bei der Gattung Quercus. Flora 90: 114–160. 1902.

THE GEOTROPIC RESPONSE in jointed plants is the subject of an extensive article by Miehe,[9] who has added much to the work done in this field by Kohl[10] two years ago. Tradescantia and Zebrina were used in a long series of experiments, which, however, cannot be even outlined here. Miehe believes he has shown that Kohl's conclusions are not well founded. Kohl's work seemed to show that two nodes were necessary for bending, the upper acting as a perceptive region while the lower was responsive. Thus in a cut portion of stem the apical node did not bend, but bending occurred in all nodes behind this. Miehe's explanation of this and other observed phenomena is that we have here to deal with an inhibition of the geotropic response in the node nearest the cut. He shows that various other factors will influence the geotropic response in a similar way. Three terms are proposed to describe these and kindred phenomena: *katatonus*, to denote a checking of power to respond normally; *anatonus*, an acceleration of this power; and *metatonus*, a complete reversal of the response. From the present paper it may be regarded as certain that the case is at least not so simple as was thought by Kohl.— BURTON E. LIVINGSTON.

HEGI[11] presents the historical features of the flora of a limited area lying within the cantons of Zurich, St. Gall, and Thurgau, Switzerland. The Miocene fossils indicate a subtropical climate at that time, while the plant remains associated with the interglacial beds record the climatic and floristic changes incident to the Pleistocene conditions. After the final retreat of the ice-sheet the associated non-glaciated areas contributed the various species which characterize the area in question today. The "xerothermische" floristic element from the Mediterranean region was at first perhaps the most effective, since the extreme cold of the Pleistocene times was apparently followed by a period of aridity and comparatively high temperatures. With the advent of the present climatic conditions the "silvestre" element (forest trees and associated vegetation) from the region northeast of the Caspian sea, became the dominant vegetative covering of the area. A third element of the flora is the class known as "glacial relicts" which, while numerous as to species, is limited as to distribution and the number of individuals. A considerable portion of the paper is given over to an annotated list of the present flora, which is based largely upon the author's personal collections and observations.— J. M. WESTGATE.

INTERESTING STUDIES on the effect of centrifugal force upon seeds and plants, with respect to both the arrangement of cell parts and the later effect upon growth have been made by Andrews[12] in the Leipzig laboratory. A centrifugal force equal to 1,400 times the force of gravity was used. Seeds subjected to this force for three or four hours were found to have their cell contents displaced. The nucleus is always of higher specific gravity than cytoplasm and cell sap, while oil drops are of lower. Starch and proteid grains, chloroplasts and chromoplasts, have, of course, a relatively high specific gravity. The cell contents of seeds so treated gradually return to their original arrangement, but in case the seeds are kept dry this process may take several months, whereas if they are planted in moist saw dust the normal condition is usually reached within a day or two. When the return of the cell contents to their usual position is slow, growth seems to be retarded also. The contents of sieve tubes can be extruded by this centrifugal force, but are reformed in time, the reformation going on twice as rapidly in light as in darkness. The methods described are apparently very good and we hope to gain more knowledge along these lines. Perhaps quantitative measurements made in this field may at length give some insight into the physics of cytology.— BURTON E. LIVINGSTON.

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[9] MIEHE, HUGO, Ueber correlative Beeinflussung des Geotropismus einiger Gelenkpflanzen. Jahrb. Wiss. Bot. **37**: 527–593. *pls. 12, 13a, 13b.* 1902.

[10] KOHL, F., Die paratonischen Wachsthumskrümmungen der Gelenkpflanzen. Bot. Zeit. **58**: 1–28. *pls. 2.* 1900.

[11] HEGI, GUSTAV, Das obere Tösstal und die angrenzenden Gebiete floristisch und pflanzengeographisch dargestellt. Bull. Herb. Boiss. II. **1**: 179. 1900; **2**: 216. 1901, 1902.

IN A RECENT PAPER Dr. Harshberger[13] reports additional observations along the New Jersey coast, incorporating in the article the results of Dr. T. S. Githens's study of the Absecon beach strand, and promising a future paper on mutation in *Hibiscus Moscheutos* L. Corn was found in the drier regions of a salt meadow at Holly beach. Along Barnegat bay wind-swept hollows occur which, when sufficiently deep to reach wet sand, are characterized by a swamp flora. Maps aid greatly in obtaining a clear idea of the distribution of species in these wind sweeps, but have the disadvantage of requiring a double translation of their legends. The appearance of fungi is accounted for by the presence of drift-wood under the dunes. *Ruppia maritima* L. found in Barnegat bay appears to be the only aquatic which can endure the alternation of fresh and salt conditions caused by the occasional entrance of the ocean through passages across the peninsula. Near Piermont occur the highest dunes of the New Jersey series (40–50 feet), back of which lies a deciduous forest. Lianes of the covered forest continue to grow upon the dune which destroyed their original support. At Sea Side Park, on account of the absence of trees, the prevailing west wind gives to the dunes a steep seaward face. The shape of the coastal trees is considered to be due more to sand-blast action than to the salt wind.—LAETITIA M. SNOW.

FIVE PAPERS dealing with the chemistry of plant life have recently been published by K. Aso. In the first of these,[14] it is shown that manganese compounds in very weak solution act as a stimulant upon radish, barley, wheat, and pea. This action was manifested in culture solutions containing manganous phosphate in a concentration of 0.002 per cent.

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[12] ANDREWS, F. M., Die Wirkung der Centrifugalkraft auf Pflanzen. Jahrb. Wiss. Bot. **38**: 1–40. 1902.

[13] HARSHBERGER, J. W., Additional observations on the strand flora of New Jersey. Proc. Acad. Nat. Sci. Phila. **1902**: 642–669.

[14] ASO, K., On the physiological influence of manganese compounds on plants. Bull. Coll. Agric. Imp. Univ. Tokyo **5**: 177–185. *pls. 14–17.* 1902.

In the next two papers[15] experiments with sodium fluorid and sodium silico-fluorid are reported. Both of these substances show a stimulation effect in very great dilution, but the latter is a much more violent poison than the former.

In the fourth paper[16] oxidizing enzymes of plants are considered. Besides the guaiac reaction for these enzymes and that with guaiacol and hydrogen peroxid, the author was able to obtain from many vegetable tissues the reaction of Storch with paraphenylendiamin and hydrogen peroxid. He also found a new reaction for oxidizing enzymes, namely, the production of a deep violet color on addition of tetramethylparaphenylendiamin and hydrogen peroxid, a reaction which was obtained from various plant tissues. Sodium fluorid and silico-fluorid interfere with the color reactions of these tests, as does also tannin, but not sugars. By addition of two volumes of absolute alcohol to one volume of plant juice, oxidase is precipitated, while most of the other oxidizing enzymes are left dissolved.

In the fifth paper,[17] the various forms of calcium in plants are treated. In potato and buckwheat only a small amount of lime compounds soluble in water are present, while in barley and clover they are more abundant. It appears that the amount of lime increases with the increase of chlorophyll.—BURTON E. LIVINGSTON.

J. C. SCHOUTE has been investigating the morphology of the stelar system of the higher vascular plants.[18] His studies relate to the histogenesis and comparative anatomy of the tissues in the flowering plants, and the work is divided into two corresponding parts.

In the first part the author describes his investigations on the structure of the stem-apex and root-apex in a number of angiosperms, and comes to the conclusion that the meristematic layers of Hanstein, the dermatogen, the periblem, and the plerome do not correspond at all accurately to the division of the tissues of the vascular plants into epidermis, cortex, and central cylinder, as proposed by Van Tieghem and others. He further finds that there is too much inconstancy in the cell wall reticulum of the growing point, especially in the case of the stem, for it to be regarded as of very great value as a clue to the morphology of the tissues. The author uses exceptionally exact methods in the study of the growing point, and takes great pains to secure exactly median and very thin sections.

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[15] ASO, K., The action of sodium fluorid upon plant life. *Ibid.* 5: 187–195. *pls. 18–19.* 1902.

———, On the action of sodium silico-fluorid upon plants. *Ibid.* 5: 197–198. 1902.

[16] ———, On oxidizing enzymes in the vegetable body. *Ibid.* 5: 207–235. 1902.

[17] ———, On the different forms of lime in plants. *Ibid.* 5: 239–242. 1902.

[18] SCHOUTE, J. C., Die Stelar-Theorie. Proefschrift, Groningen, December 1902.

In the second part he describes his examination of the stems of a large number of dicotyledons and monocotyledons, for the presence of an endodermis (phloeoterma of Strasburger), and from his own observations and the literature of the subject draws up a comprehensive tabular view of the occurrence of this layer. He finds, contrary to Fischer, that an endodermis is a very constant feature of the stem in monocotyledons, being present in 18 families out of 19 investigated. In the case of the dicotyledons, it was present in 99 out of 169 families. The author draws the conclusion that the endodermis is a very important layer morphologically. Taking into consideration the recent work on the ontogeny of the central cylinder, he agrees with Boodle, that the central cylinder of all vascular plants is morphologically the same, viz., monostelic.—E. C. JEFFREY.

WILLIS,[19] in continuing his studies of the oriental Podostemaceae, has published a most interesting account of the habits and ecological relations of the Ceylonese and Indian forms. All members of the family live in rapidly moving water, usually in the rapids and waterfalls of mountain streams. In general they are attached to rocks, each species affecting a particular habitat, determined by speed, depth, and roughness of the water. These various factors are fully described under each species. The most problematical and characteristic structure of the group is the so-called "thallus," a creeping dorsiventral organ developed from the primary axis, and itself bearing endogenous secondary shoots. In different genera the thallus seems to be of different morphological value, but in the main it has been regarded as a root structure, which raises a question as to the essential character of a root. In any event, the function of the thallus, which often resembles an alga, a lichen, or a liverwort, is to spread rapidly over rocks, developing new shoots at short intervals, and holding them in the swiftly running water until they can form holdfasts of their own.

Probably the most significant part of the paper is the discussion of the dorsiventrality of the group, no other family above liverworts showing so marked and far-reaching a dorsiventrality in organization. The author presents a series of forms passing from the least modified forms, in which dorsiventrality is only expressed by the position of the thallus, to the most highly modified forms, in which dorsiventrality appears in every part, even in the embryo. The very interesting conclusion is reached that, as in the whole family dorsiventrality appears first in the vegetative organs and then includes other members, the dorsiventrality of the flowers, which is the most important diagnostic feature of the family, is a direct result of that of the vegetative organs; in other words, that the dorsiventrality of the floral organs has been forced upon them by that of the vegetative organs, without any reference to the advantages or disadvantages to be derived from it in the performance of the functions of the floral members themselves. The whole paper, accompanied by its numerous well-executed plates, must be read in order to get its full bearing upon several important problems.—J. M. C.

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[19] WILLIS, J. C., Studies in the morphology and ecology of the Podostemaceae of Ceylon and India. Ann. Roy. Bot. Gardens Peradeniya 1 : 267–465. *pls. 4–38.* 1902.

ITEMS OF TAXONOMIC INTEREST are as follows: P. HENNINGS (Hedwigia **41**:295–311. 1902) has described the new genera *Capnodiopsis* (Capnodiaceae) and *Pseudobeltrania* (Dematiaceae), from the Puttemans's collection of the fungi of São Paulo, and also (Beiblatt Hedw. **41**: 209–215. 1902) a new genus (*Battareopsis)* of Secotiaceae from the Schweinfurth Egyptian collection of 1901–1902.—R. CHODAT and E. WILCZEK (Bull. Herb. Boiss. II. **2**: 527. 1902) have described a new genus (*Oligocladus*) of Umbelliferae (Peucedani) from Argentine.—F. B. FORBES and W. B. HEMSLEY (Jour. Linn. Soc. **36**: 1–72. 1903), in the current part of their enumeration of all the plants known from China proper, Formosa, Hainan, Corea, the Luchu Archipelago, and the island of Hong Kong, enumerate 352 species of Orchidaceae, including 23 new species and a new genus (*Hancockia* Rolfe).—N. BRYHN (Nyt Mag. Naturvidensk. **40**: 204–208. *pls. 1–2.* 1902) has described a new genus (*Sarconeurum*) of mosses (Pottiaceae) from the antarctic collections made on the Borchgrevink expedition of 1898–1900.—A. P. MORGAN (Jour. Mycol. **8**:169. 1902) has described a new genus (*Sporocystis*) of Tuberculariaceae from Ohio, and has also (*idem* 179–192) published a list of the Discomycetes of the Miami valley, Ohio, including 128 numbers, 7 of them being new species.—J. B. ELLIS and E. BARTHOLOMEW (*idem* 173–178), in describing 23 new species of fungi from various localities include a new genus (*Stachybotryella*) near Stachybotrys, from Austin, Texas.— ANNA MURRAY VAIL (Bull. Torr. Bot. Club **29**: 662–668. *figs. 7.* 1902), in her sixth "Study" of Asclepiadaceae, has defined and illustrated 7 species of Rouliniella, 3 of them being new.—L. M. UNDERWOOD (*idem* 669–679), in his fifth paper on American ferns, has published a review of Danaea, recognizing 12 species, 5 of which are new.—P. A. RYDBERG (*idem* 680–693), in his ninth "Studies on the Rocky Mountain Flora," has taken up the Nyctaginaceae, describing new species of Abronia (6) and Allionia (3), and establishing a new genus (*Allioniella*) on *Allionia oxybaphoides*.—ALICE R. NORTHROP (Mem. Torr. Bot. Club **12** : 1–98. *pls. 1–19.* 1902), in her account of the flora of two of the Bahama islands (New Providence and Andros), includes two new genera of palms (*Paurotis* and *Cyclospathe*) described by O. F. Cook, besides new species of Aletris, Hymenocallis, Vanilla, Pithecolobium, Cassia, Linum, Erythroxylon, Crassopetalum, Helicteres, Xylosma, Terminalia, Metastelma, Heliotropium, Tecoma, Catesbaea, Myrstiphyllum, Anguria, and Eupatorium; also a new species of Thrinax by O. F. Cook, and of Phoradendron by I. Urban.—KARL MÜLLER (Bull. Herb. Boiss. II. **3**: 34–44. *pl. 1.* 1903) has described several new species of Scapania from North America.—J. M. C.

RECENT CONTRIBUTIONS TO AMERICAN PHYTOGEOGRAPHY: the Central United States. W. L. BRAY published in this journal (BOT. GAZ. **32**: 99–123, 195, 217, 262–291. 1901) a most valuable paper on the ecological relations of the Texas vegetation.—W. H. LONG'S work on the distribution of fungi about Austin, Tex., has been previously noted (BOT. GAZ. **30**: 429. 1900).—C. H. FITCH (U. S. Geol. Surv. Ann. Rept. **21**: 603–672. 1900) has given a detailed description, section by section, of the woodlands of Indian Territory. —K. K. MACKENZIE and B. F. BUSH, in their manual of the flora of Jackson county, Missouri, previously mentioned in this journal (BOT. GAZ. **34**: 310. 1902), list a number of ecological habitats with their characteristic species.—J. M. WESTGATE (Science **15**: 462. 1902) traces the genetic development of the vegetation on an island in the Kansas river, giving the results of a four years' study. There have been rapid changes from xerophytic to mesophytic conditions, and these changes have been recorded by serial photographs. The actual succession of plants, as witnessed from year to year, confirms comparative studies made elsewhere.

B. SHIMEK (Proc. Iowa Acad. Sci. **7**: 47–59. 1899) discusses in a most suggestive manner the distribution of forest trees in Iowa. He reviews the various theories that have been supposed to account for the treelessness of prairies, giving in footnotes a large number of citations. The fire theory has had the larger number of adherents; too much emphasis has been given to this cause, but the author thinks it of some value. Lesquereux's swamp theory explains some prairies, but not those on loess hills. Insufficient atmospheric moisture is of much importance, but cannot explain the alternation of prairie and forest in eastern Iowa. The soil character has some place. The author rightly holds that most writers have erred chiefly in holding to one theory, and discarding others. He accepts all of the above theories as of more or less value, and adds some further notes on the influence of wind, which he thinks has been too little dwelt upon. This, Shimek holds, explains the preponderance of trees in eastern Iowa, where the winds are less vehement. The wind theory accounts for trees in sheltered situations along streams, also for their relative absence on the Iowa side of the Missouri river, as compared with the Nebraska side. Tree planting experiments yield similar data.—L. H. PAMMEL (Pharm. Rev. **19**: 117, 156. 1901) gives the northern limits within Iowa of several trees of southern range, and in his *Grasses of Iowa* (see BOT. GAZ. **32**: 429. 1901) discusses the pastures, meadows, and weeds of the state, chiefly from an economic aspect.

ROSCOE POUND and F. E. CLEMENTS'S admirable Phytogeography of Nebraska has been previously reviewed in this journal (BOT. GAZ. **25**: 370. 1898; **32**: 374. 1900).—C. E. BESSEY (Forester **6**: 240–243. 1900; see BOT. GAZ. **31**: 133. 1901) has treated in an interesting manner the natural spreading of timber areas in Nebraska. He finds that the pines in the northwest, and the deciduous trees in the east are extending their domain with some rapidity. This he attributes chiefly to the restriction of prairie fires in recent years. The pines spread easily without the aid of other plants, but the deciduous trees come up under a cover furnished by roses, plums, and other shrubs; these in turn are preceded by herbaceous plants. The same author (*idem* 7:314–319. 1901) discusses the distribution of twenty native forest trees of Nebraska. As Professor Bessey has previously shown, most of these trees have doubtless migrated from the east along the Missouri river; probably more than fifty species have entered the region in this way, while but ten species have migrated eastward from the mountains. The maps, especially those showing the oaks and hickories, are very suggestive. The author has considered the same subject more fully in another paper (Nebr. State Board of Agric. Ann. Rept. **1899**: —. 1900). In the fifteenth annual report of the botanist (1901), entitled "Some Agricultural Possibilities of Western Nebraska," Professor Bessey gives an account of the physical features and the vegetation of the sand hills and foothills. In the sand hills there are twenty-four species of trees, mostly of eastern affinities, and growing chiefly in cañons or along the rivers. Forty-eight shrub species occur, twenty of which are of western affinities. The grasses are fully considered. In the foothills there are twenty species of trees occurring on the ridges and in the cañons. More western forms (but not a majority) are found than in the sand hills. Professor Bessey (Science **14**: 185–187. 1901) gave an itinerary for botanists en route to Denver, showing what could be seen from the car window in Nebraska. He also (*idem* 721–724) wrote concerning the early winter colors of the plant formations on the plains, noting the wide range of color aspects and the color tendencies of various formations.—W. L. HALL (Forester 7:188–193. 1901) tells of the interesting tree planting experiments being made in Nebraska.—J. J. THORNBER (Bot. Surv. Neb. V. 1901) has made a statistical study of the prairie-grass formation in region I, near Nebraska City. Physical data of various sorts were collected, phenological observations were carefully made, and the various habitat-groups were studied. An interesting point brought out in the discussion of ecological factors is the much more favorable light relation in woods than in thickets. The body of the paper is on the structure of the formation, in which the controlling species are mentioned in the different habitats. A feature of the paper (wanting in many studies because an account of a region is made as a result of a week's study) is the presentation of the aspect of the prairie, season by season (prevernal, early vernal, late vernal, early estival, late estival, serotinal). A vast number of counts and diagrams of individuals in selected quadrants completes the paper.—G. G. HEDGCOCK (*idem* VI, 1902) has studied the relation of the water content of the soil to certain plants, principally mesophytes. Among other results he finds that plants wilt and die in saline soils, while the per cent. of water is still relatively high, whereas in sand the per cent. of water at which plants wilt or die is lower than in other soils. Seedlings grown in sand are more turgid than those grown in humus. The most watery plants are often the least vigorous.

Dying xerophytes contain but little water; while dying hydrophytes contain much; hydrophytes lose water more rapidly than the soil, xerophytes less so. The per cent. of non-available water in a soil increases as the square root of the per cent. of the soluble salts.

W. A. WHEELER (Minn. Bot. Stud. 2: 353–416. 1900) has written an ecological account of the vegetation of southeastern Minnesota. He notes a wide difference between the vegetation of river and creek valleys. The north-facing slopes, as so often is the case, have the climax vegetation of the region. The moist cliffs contain some rare mountain plants, and some southern trees find here their northern limit. The same author (*idem* 569–600. 1901) has presented a contribution dealing with flora of the Red river valley in Minnesota. Some interesting halophytes and semi-halophytes are recorded. Both articles are most beautifully illustrated with heliotypes, which are fully described.—D. LANGE (*idem* 621–630. 1901) gives an account of the revegetation of Trestle island in Lake Phalen, Minn. This island was exposed in 1898 and its successions of forms for three years are recorded.—B. FINK (*idem* 657–709. 1902) continues his study of the lichens of Minnesota, dealing here with those of the northwestern portion of the state. Lists of characteristic species of sixteen rock, tree, and soil formations are given, together with the characteristic adaptations. He discriminates between granitic and limestone formations, and between exposed and shaded portions in each; between rough and smooth-barked trees; between live, dead, and rotten wood; between upland and swamp trees (this seems especially interesting, since Usnea dominates in each case, but with a much greater luxuriance in tamarack swamps), etc. The author thinks that light and moisture are much more important factors in lichen distribution than are either chemical or physical characters of the substrate. It is to be hoped that many more such papers will be published, as the reviewer believes that lichens are the most favorable of all plants for working out problems of distribution. —J. M. HOLZINGER (Plant World 4: 185–187. 1901) notes some interesting cases of the local distribution of mosses in southeastern Minnesota, far from their normal range. This occurrence is in the driftless area, and these plants may well be relicts from preglacial days.—H. B. AYRES (U. S. Geol. Surv. Ann. Rept. 21: 673–689. 1900) has discussed from an economic standpoint the timber conditions of the pine region of Minnesota. An excellent map accompanies the paper.—H. C. COWLES.

NEWS.

PROFESSOR C. R. BARNES has returned to his post after a vacation of nine months. In the course of travel he visited many of the botanical establishments of Europe.

DR. J. C. ARTHUR was granted leave of absence by Purdue University and spent January and part of February at the New York Botanical Garden in studying the genera and generic types of the Uredineae.

DR. KARL GUSTAV LIMPRICHT, the bryologist, died October 20, 1902, at the age of 68 years. His monumental work is the uncompleted *Laubmoose Deutschlands Oesterreichs und der Schweiz*, of which, however, only supplementary parts remain to be published.

MISS LOUISE BRISBIN DUNN, tutor in botany in Barnard College, Columbia University, died suddenly of heart disease early on the morning of December 18. She was a graduate of Barnard and since her graduation has been a member of the teaching staff. — *Science.*

MR. A. E. DICKEY of Indianapolis has recently endowed the biological library of De Pauw University. The endowment is in the form of a memorial to Mr. Dickey's father, the late Governor Alfred Dickey, of North Dakota, and the library will hereafter be known as the Alfred Dickey Biological Library. Mr. A. E. Dickey is a graduate of De Pauw University of the class of '94.

MESSRS. HENRY HOLT & CO. announce that Kerner and Oliver's *Natural History of Plants* will no longer be published in four parts, but that in future it will be issued in a lower priced edition in two volumes. The new edition will lack only the colored illustrations of the former more expensive one, which were inserted mainly for embellishment, but retains all the other illustrations, which were an essential part of the work.

AT THE last convocation of the University of Chicago it was announced that a gift of $20,000 had been made to increase the biological library, which now numbers only about 12,000 volumes. The money being immediately available, a committee is already directing the expenditure. All imperfect sets of periodicals will be completed as far as possible, new series will be purchased and maintained, and the balance will be applied to the purchase of single works. The gift will greatly improve the library facilities in the biological departments.

ONE OF THE recent important investigations undertaken by the Bureau of Forestry, U. S. Department of Agriculture, is a study of the relationship of forests to stream-flow in the Rock River watershed of Illinois and southeastern Wisconsin. For some years a marked decrease has been noticed in the flow of this river, especially during the more critical parts of the summer and autumn. The investigation which the Bureau of Forestry made of this watershed shows that the diminished flow of the river can be traced to several distinct causes. The most important of these are the changes that have taken place in the area and the condition of the forests.

THE BOARD OF TRUSTEES of the Carnegie Institution has made an appropriation of $8,000 for the establishment and maintenance of a desert botanical laboratory for the fiscal year 1902–3, and at the request of the Executive Committee of the Institution Dr. D. T. MacDougal, Director of the Laboratories, has been permitted to serve with Mr. Frederick V. Coville, Chief of the U. S. Department of Agriculture, as an advisory board in relation to this undertaking.

The desert laboratory has been established for the purpose of making a thorough investigation of the physiological and morphological features of plants under the unusual conditions to be found in desert regions, with particular reference to the relations of the characteristic vegetation to water, light, temperature, and other special factors.

A resident investigator, to be placed in immediate charge of the laboratory, will begin a series of researches upon certain more important problems outlined by the board, and facilities will be provided by the aid of which a few other investigators from any part of the world may carry on work upon any problem connected with desert plants.

North America contains more than a million square miles of territory known to the geologist, geographer, and botanist as desert. The conditions offered vegetation in these districts show such wide departures from those of humid temperate and tropical regions, the living flora is accessible to so few workers, and the entailed investigations are necessarily so wide in scope, and so expensive and difficult in execution, that the advance of systematic knowledge of the fundamental processes of desert plants has been comparatively slow, and this lack of information has made many current generalizations concerning the activity of plants very unsafe. The establishment of this laboratory promises results concerning the fundamental processes of plant protoplasm as important as any in the whole realm of botany, and withal results which once known and incorporated in the science of botany might well offer facts of the greatest value not only to the inhabitants of the arid regions of America, but to the people of other desert regions as well, since no similar inquiry has yet been instituted in any part of the world.—*Jour. N. Y. Bot. Garden.*

DR. W. A. CANNON has been selected as resident investigator of the Desert Botanical Laboratory of the Carnegie Institution. Mr. Frederick V. Coville and Dr. D. T. MacDougal started on January 24 to make an inspection of the region along the Mexican boundary from the Pecos river in Texas to the Pacific Ocean, for the purpose of fixing on a site.

THE GATHERING of botanists at Washington during "Convocation Week" was the largest that has ever occurred in the history of this country. Besides the meetings of Section G, A. A. A. S., and its informal Botanical Club, meetings were held of the Society for Plant Morphology and Physiology and of the Botanical Society of America. Over one hundred professional botanists were registered, and it is safe to say that at least fifty others more or less directly interested in botanical matters were in attendance.

Before Section G, Mr. F. V. Coville presiding, the retiring president, Dr. D. H. Campbell, of Leland Stanford University, gave an address on "The evolution of land plants." About twenty five papers were admitted to the program and read in full or by title. The sessions closed on Wednesday. Professor T. H. Macbride was elected president for the next meeting, which is to be held in St. Louis December 28, 1903–January 2, 1904. Dr. F. E. Lloyd was elected secretary for five years.

The Society for Plant Morphology and Physiology met on Tuesday and Wednesday. Eighteen papers were read in full; seven others were presented by title. The proposed central bureau of the Association Internationale des Botanistes was discussed, and the decision was unanimous that the proposed bureau would not be useful in proportion to its cost and the labor of maintaining it. The following were elected members: W. A. Cannon, New York Botanical Garden; Judson F. Clark, Cornell University; G. P. Clinton, Connecticut Experiment Station; W. C. Coker, University of North Carolina; C. C. Curtis, Columbia University; E. J. Durand, Cornell University; J. E. Kirkwood, Syracuse University; W. A. Orton, Department of Agriculture, Washington; K. M. Wiegand, Cornell University. Dr. Roland Thaxter, of Harvard University, was elected president; Professor Conway MacMillan, of the University of Minnesota, vice-president; and Professor W. F. Ganong, of Smith College, secretary-treasurer. Thirty-five members were in attendance.

The Botanical Society of America met on Wednesday afternoon and Thursday. The retiring president, Dr. J. C. Arthur, of Purdue University, gave an address, illustrated by lantern slides, on "Problems suggested by cultures of the Uredineae." Forty papers were read in full or by title. No new members were elected on account of the defective report of the committee on membership. A committee was appointed to confer with similar committees from other botanical societies, for the purpose of securing cooperation and, if possible, federation. Dr. C. R. Barnes, of the University of Chicago, was elected president; Mr. J. N. Rose, of the U. S. National Museum, vice-president; Dr. D. T. MacDougal, of the New York Botanical Garden, secretary; and Dr. Arthur Hollick, of the New York Botanical Garden, treasurer.

The botanists of the central states organized themselves into a society, electing Professor Conway MacMillan, of the University of Minnesota, president, and Dr. C. F. Millspaugh, of the Field Columbian Museum, Chicago, secretary. Arrangements for the next meeting are left to an executive committee.

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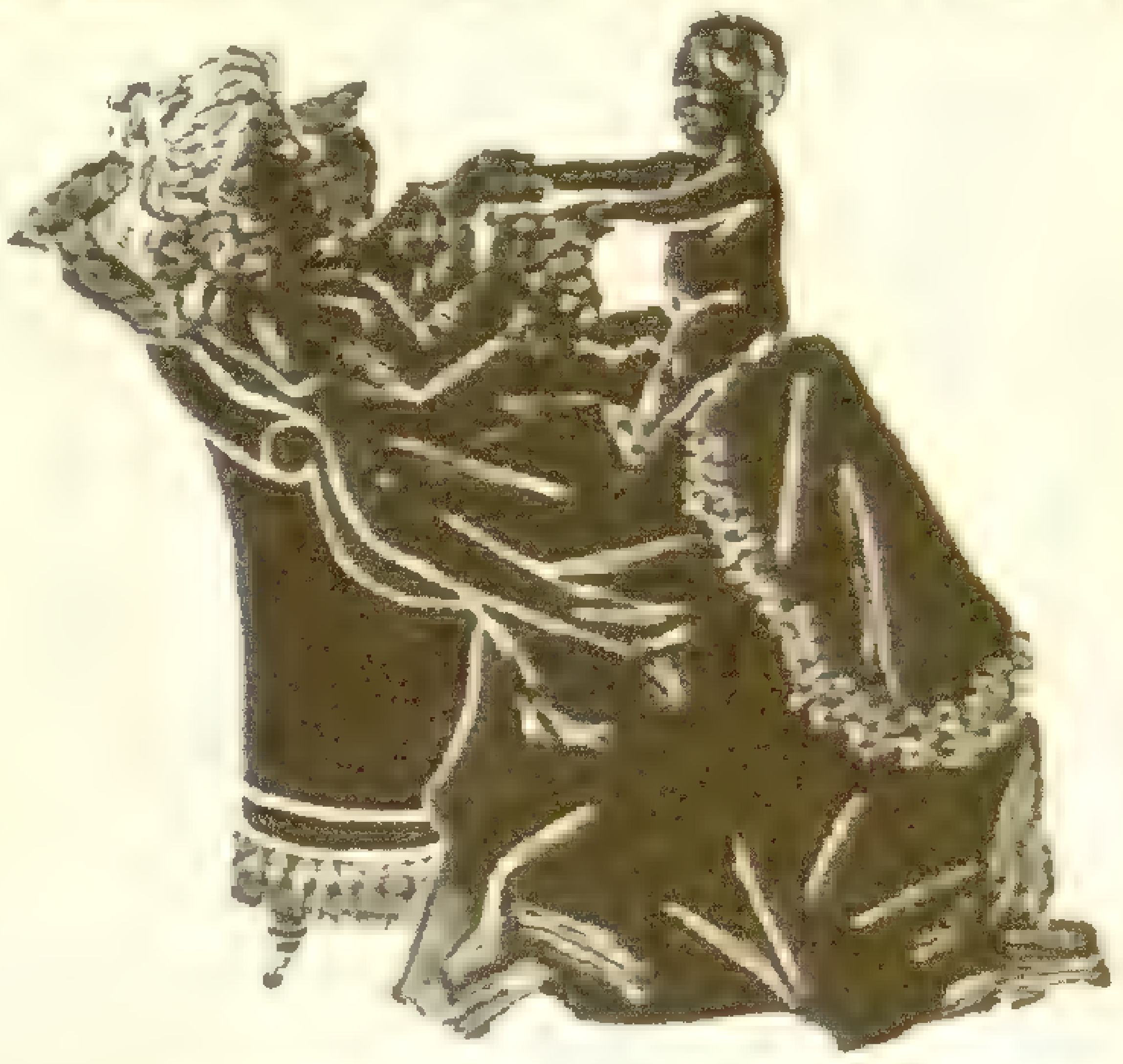

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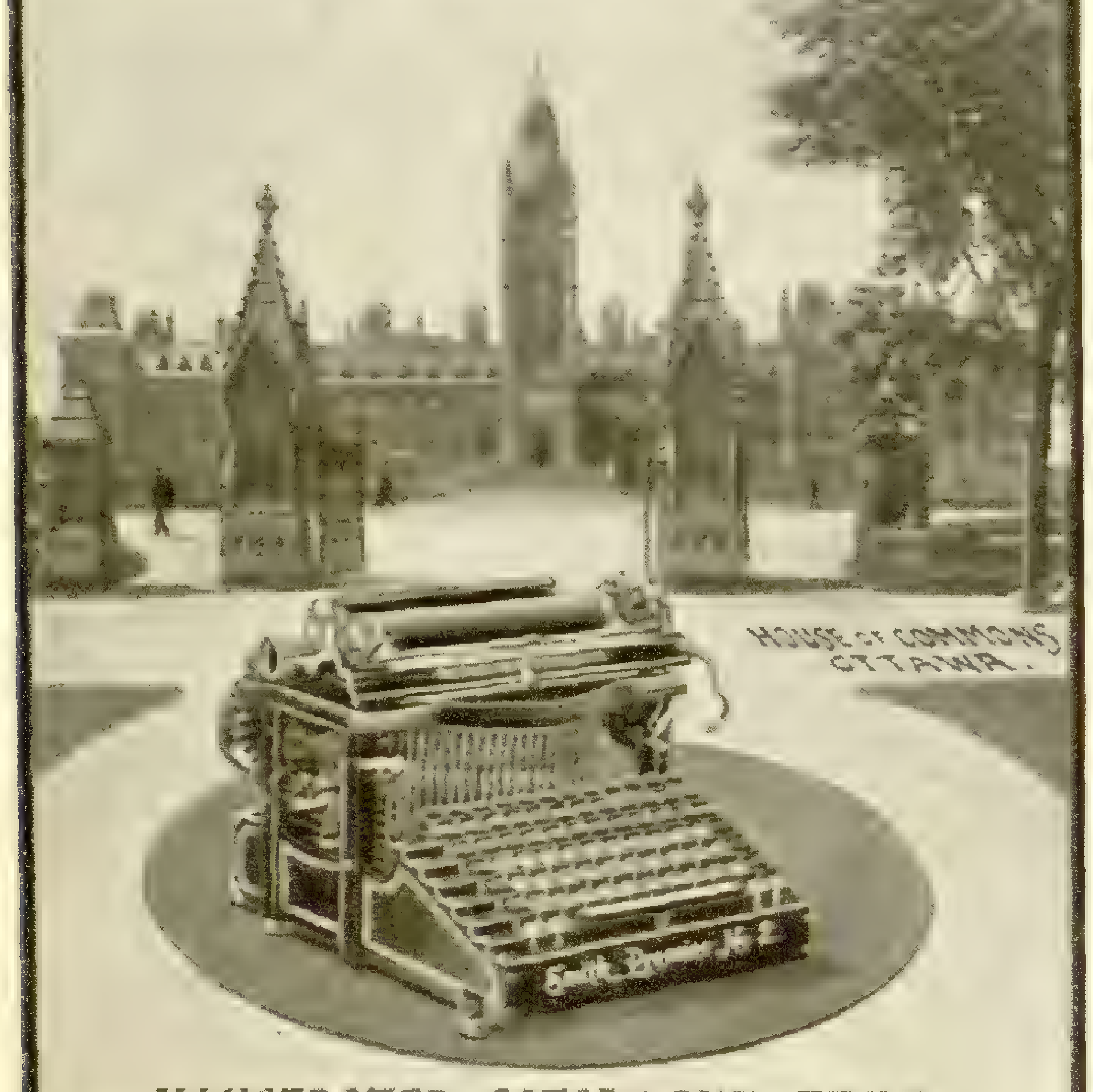

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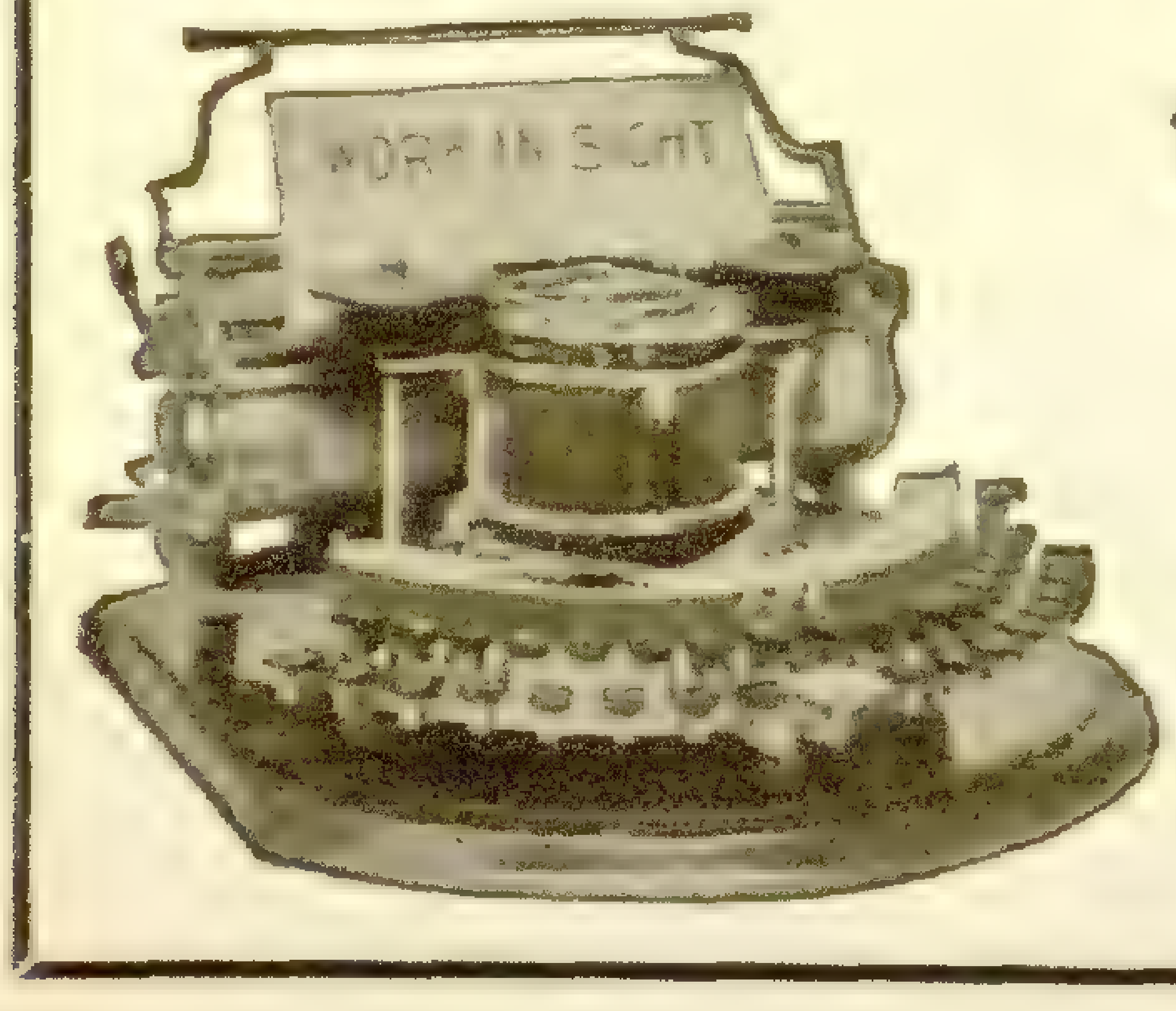

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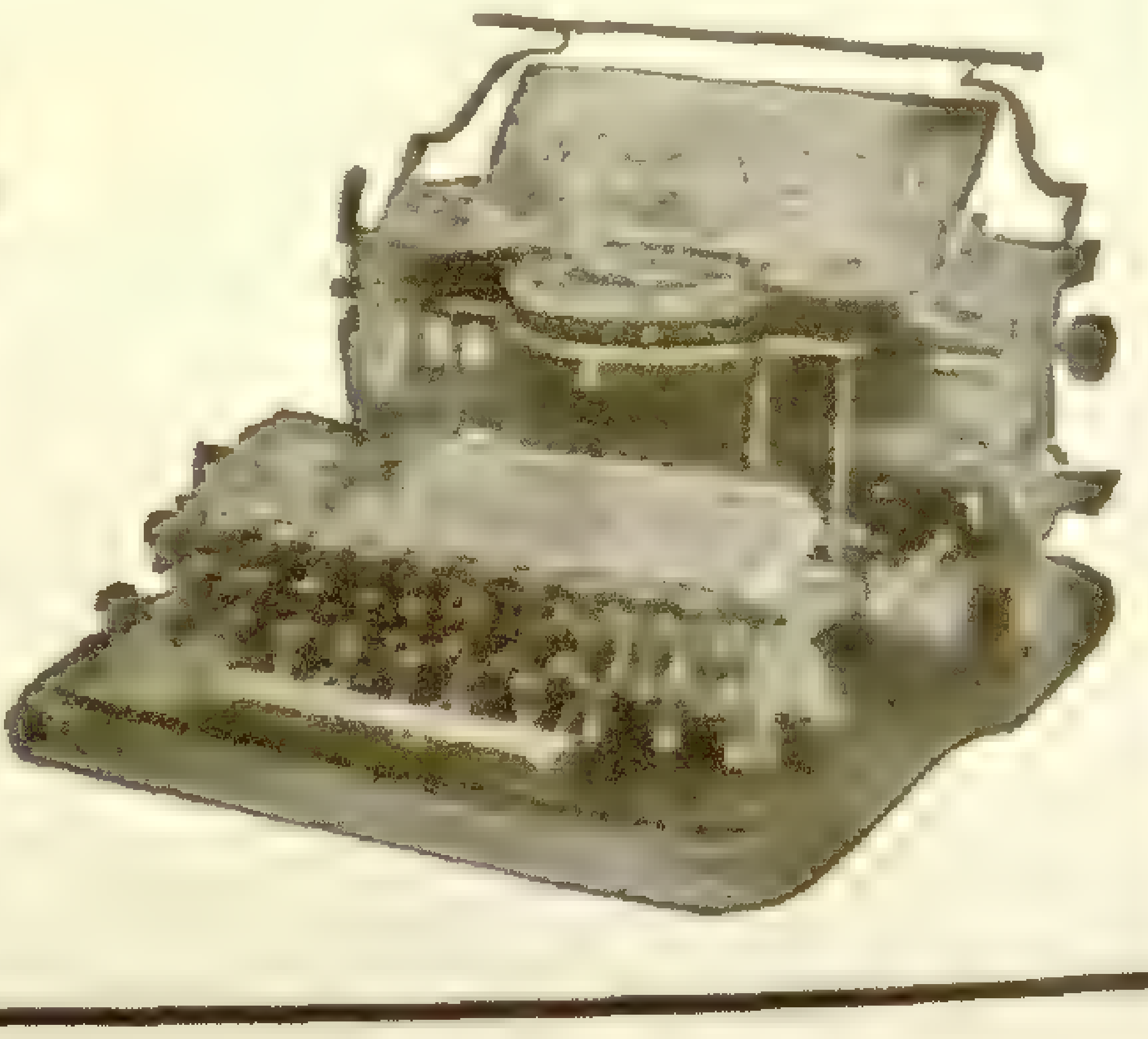

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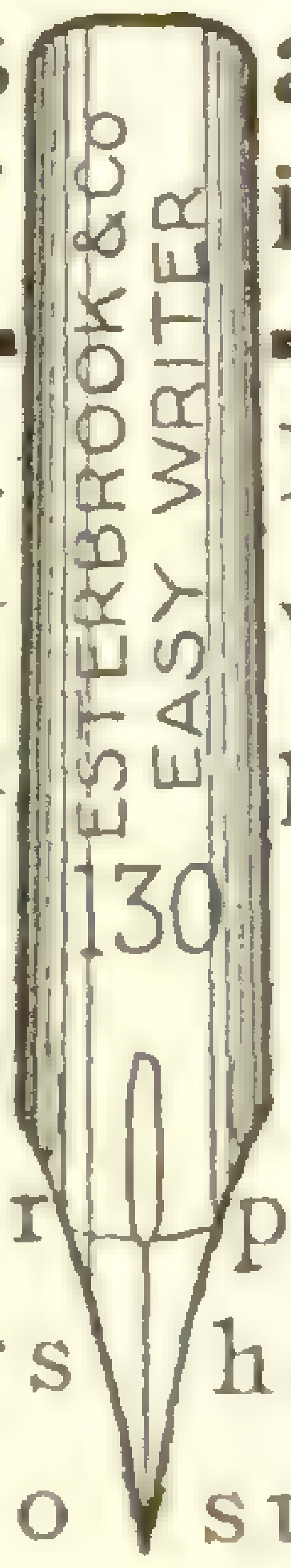
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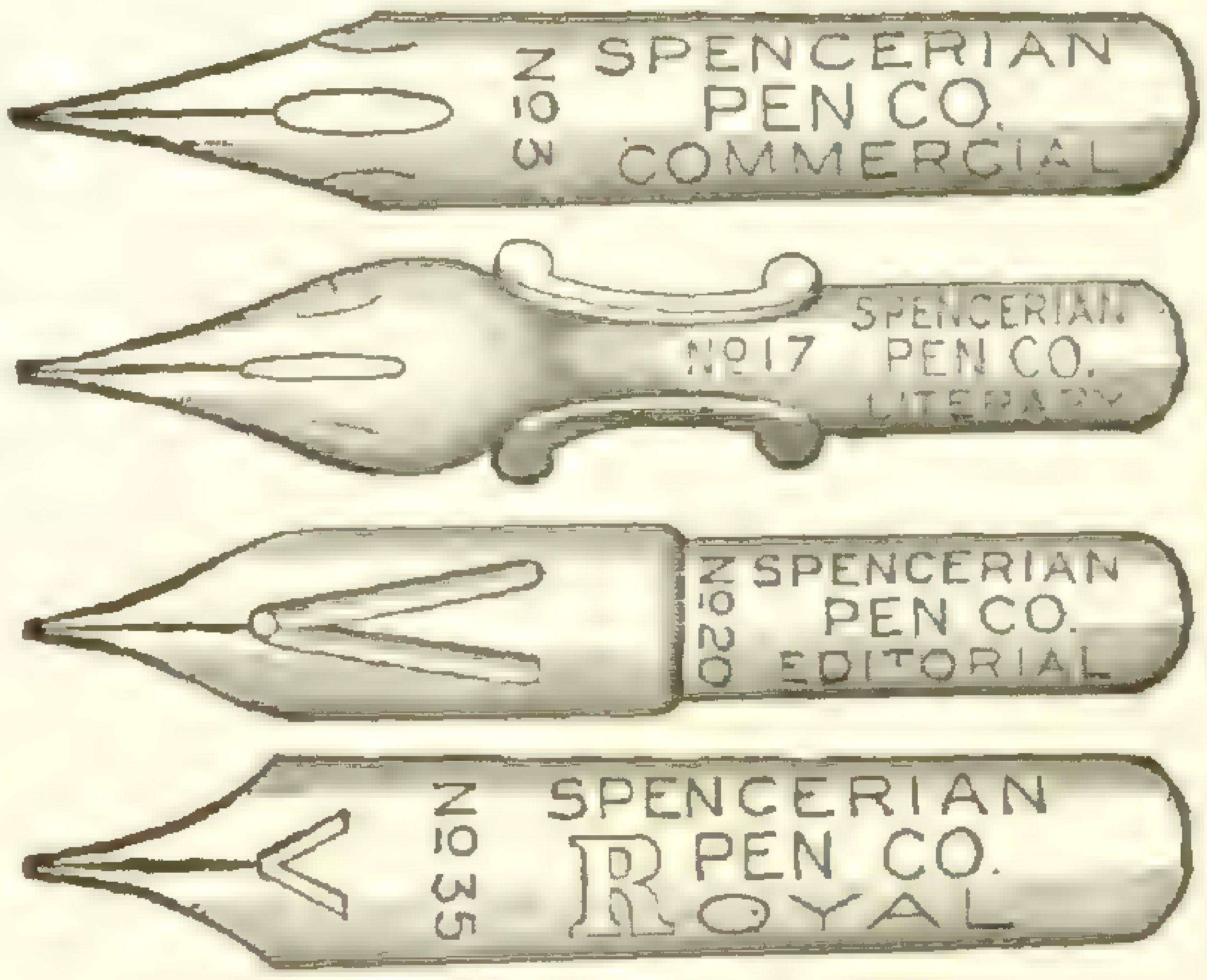
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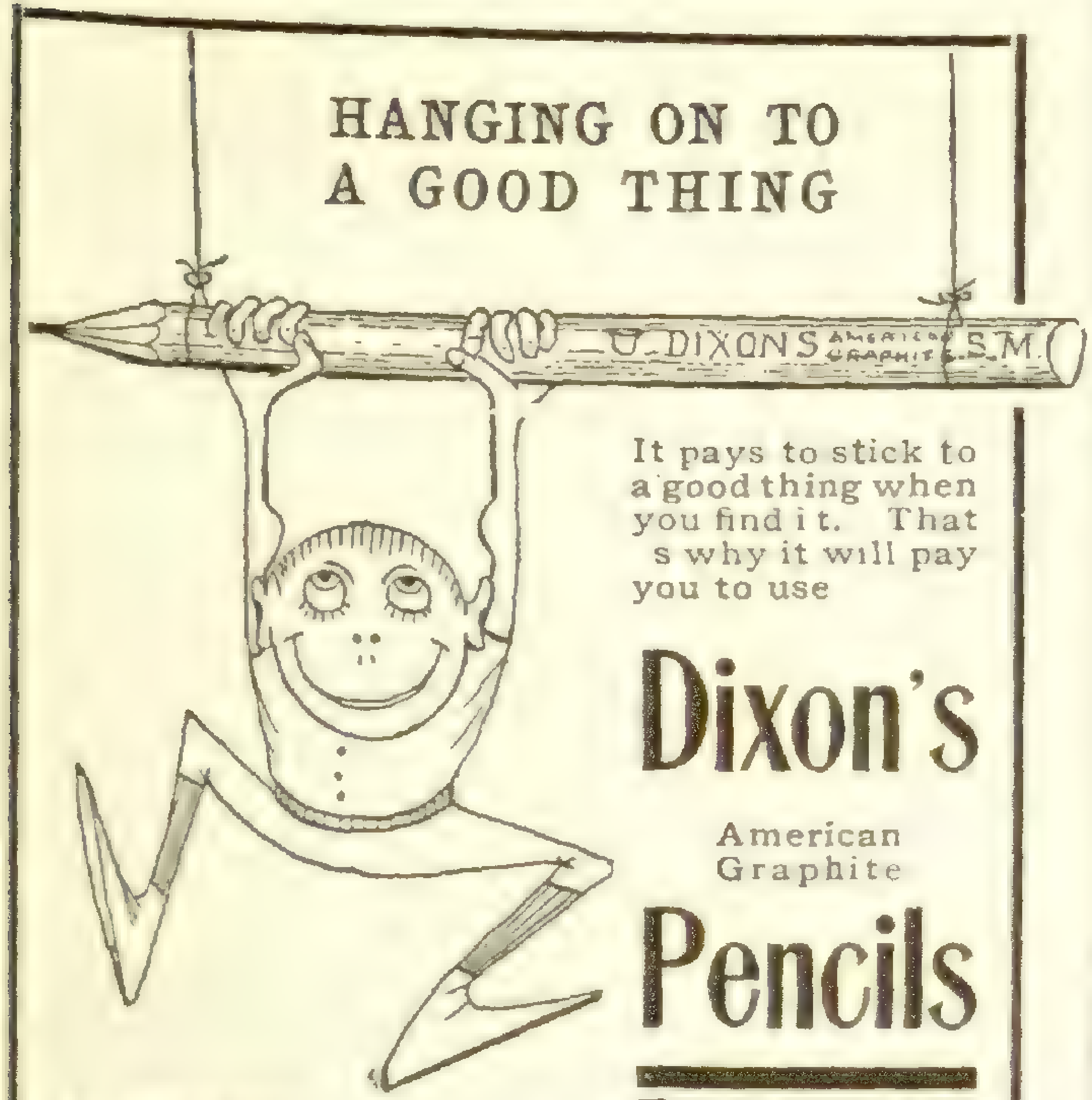
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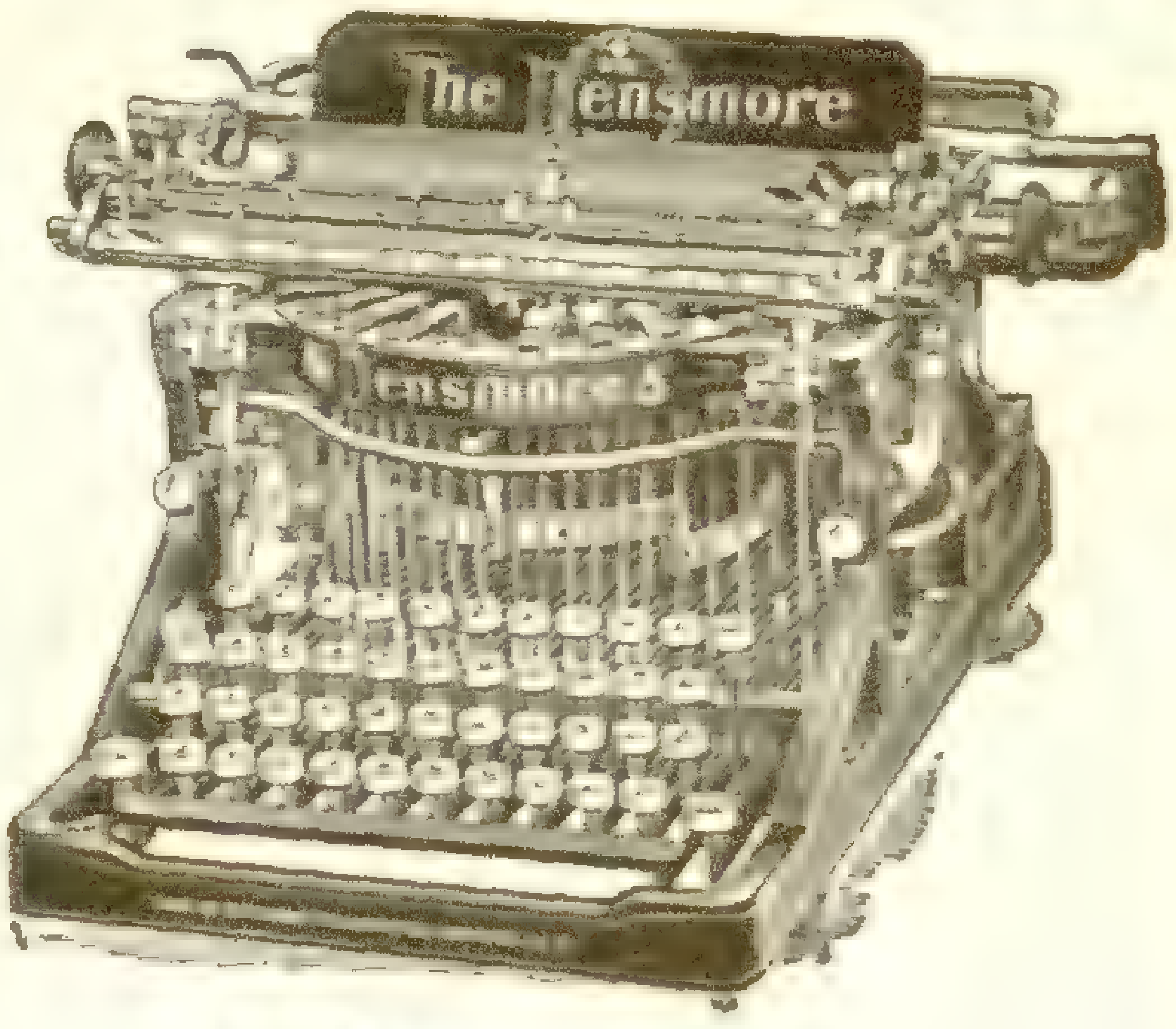
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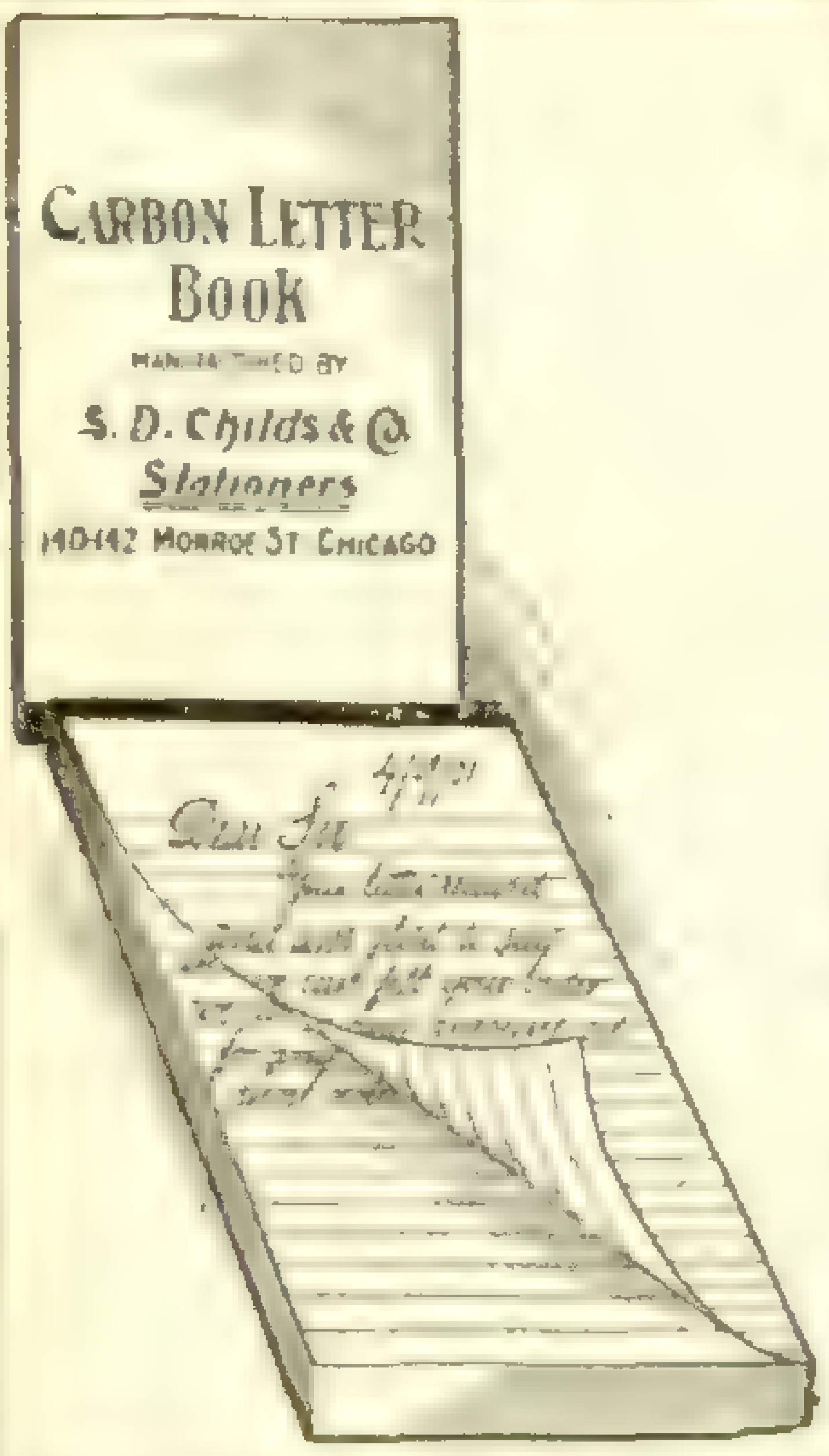

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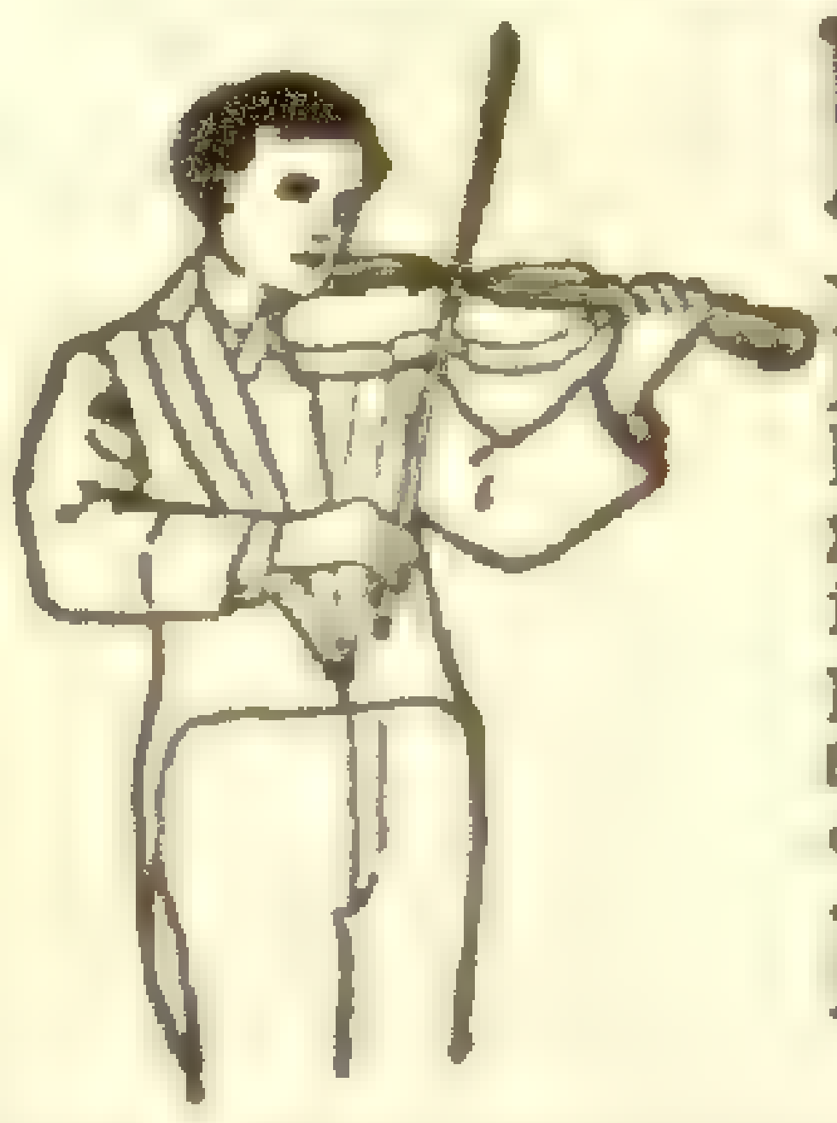

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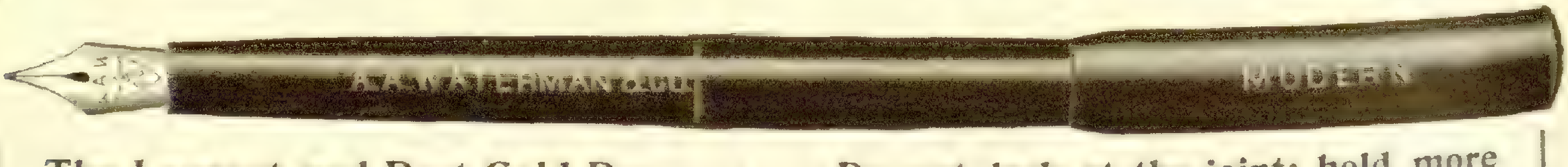

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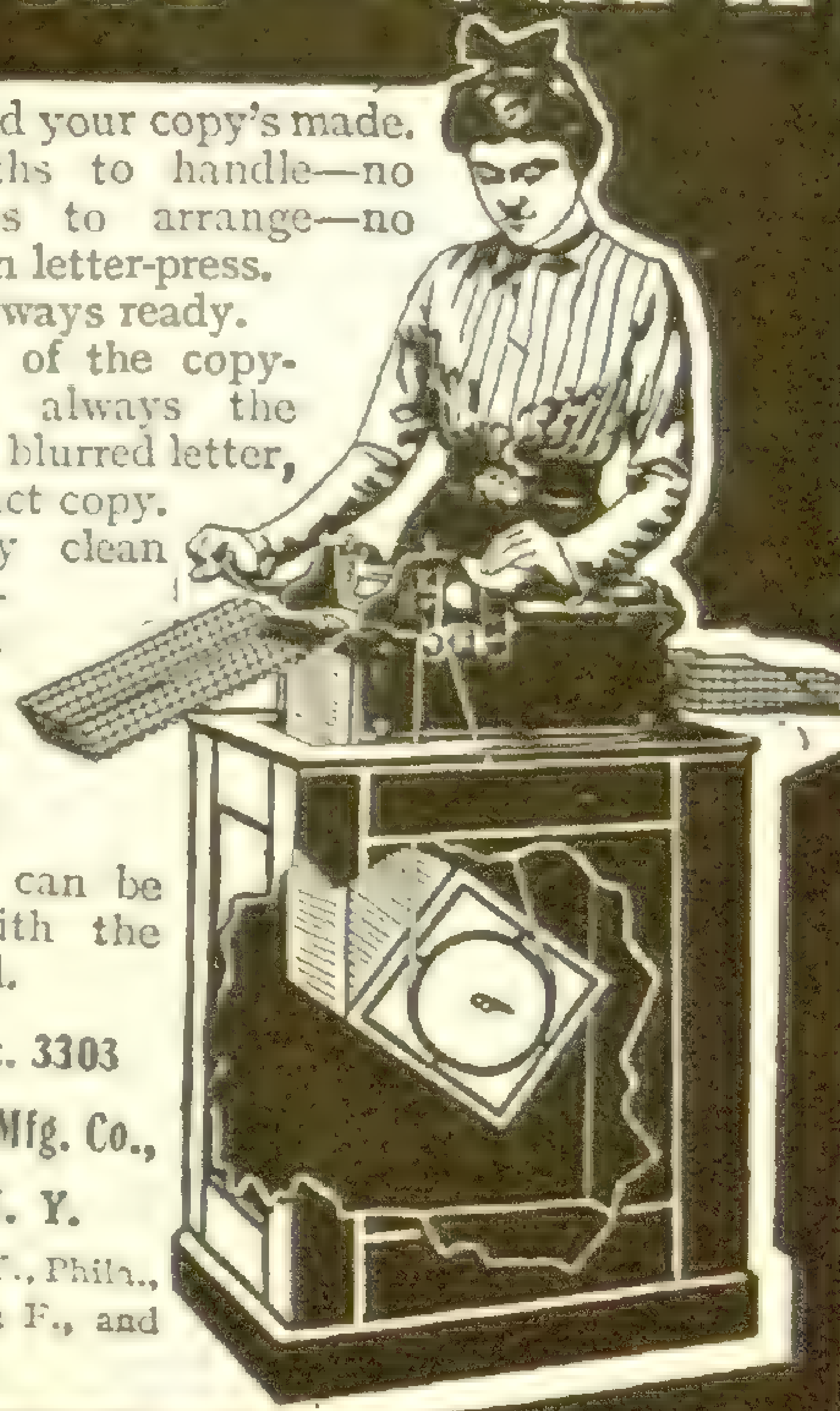

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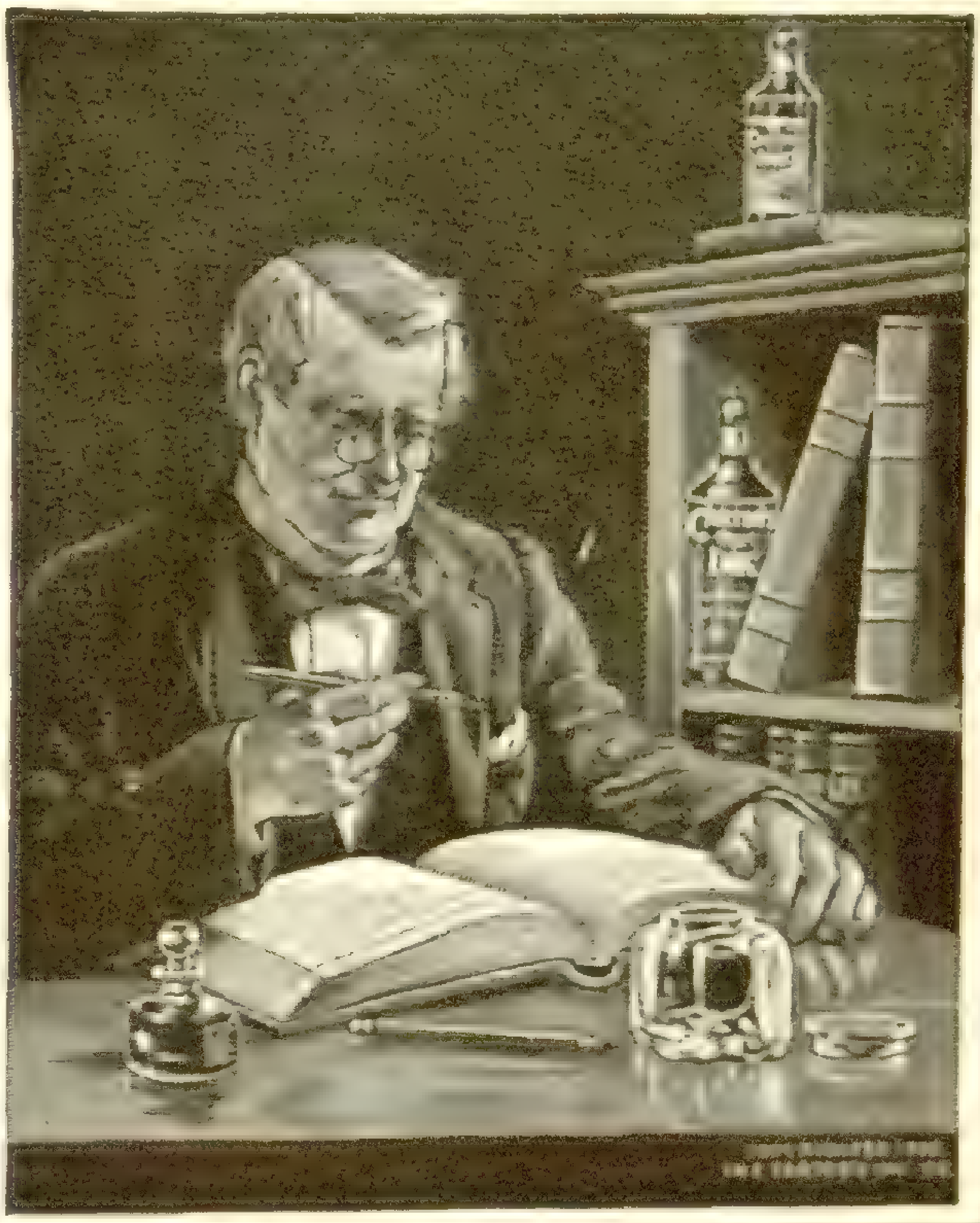

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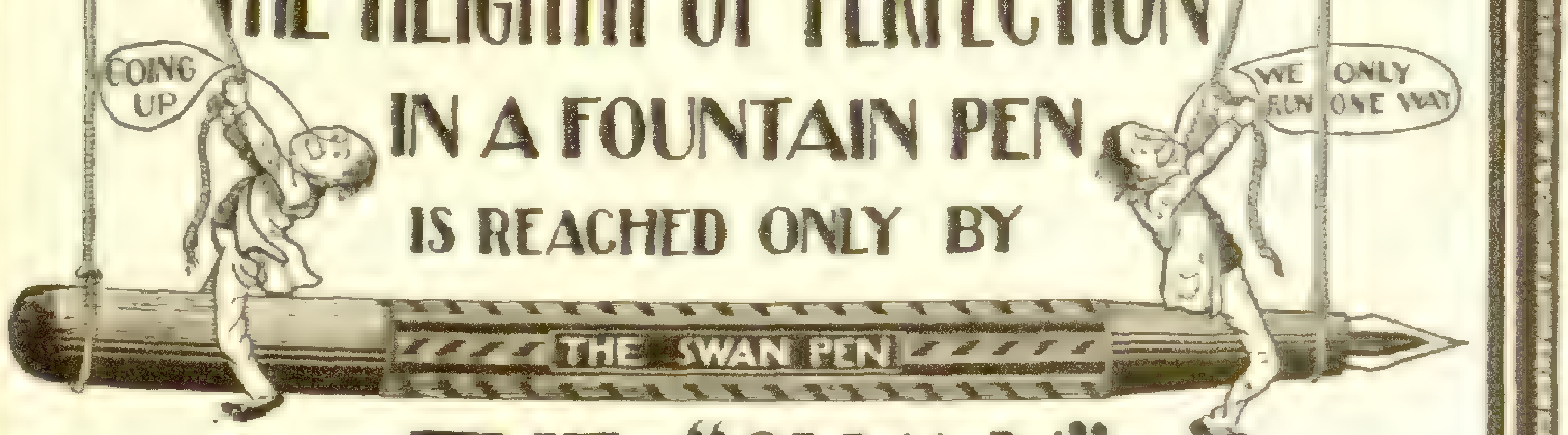

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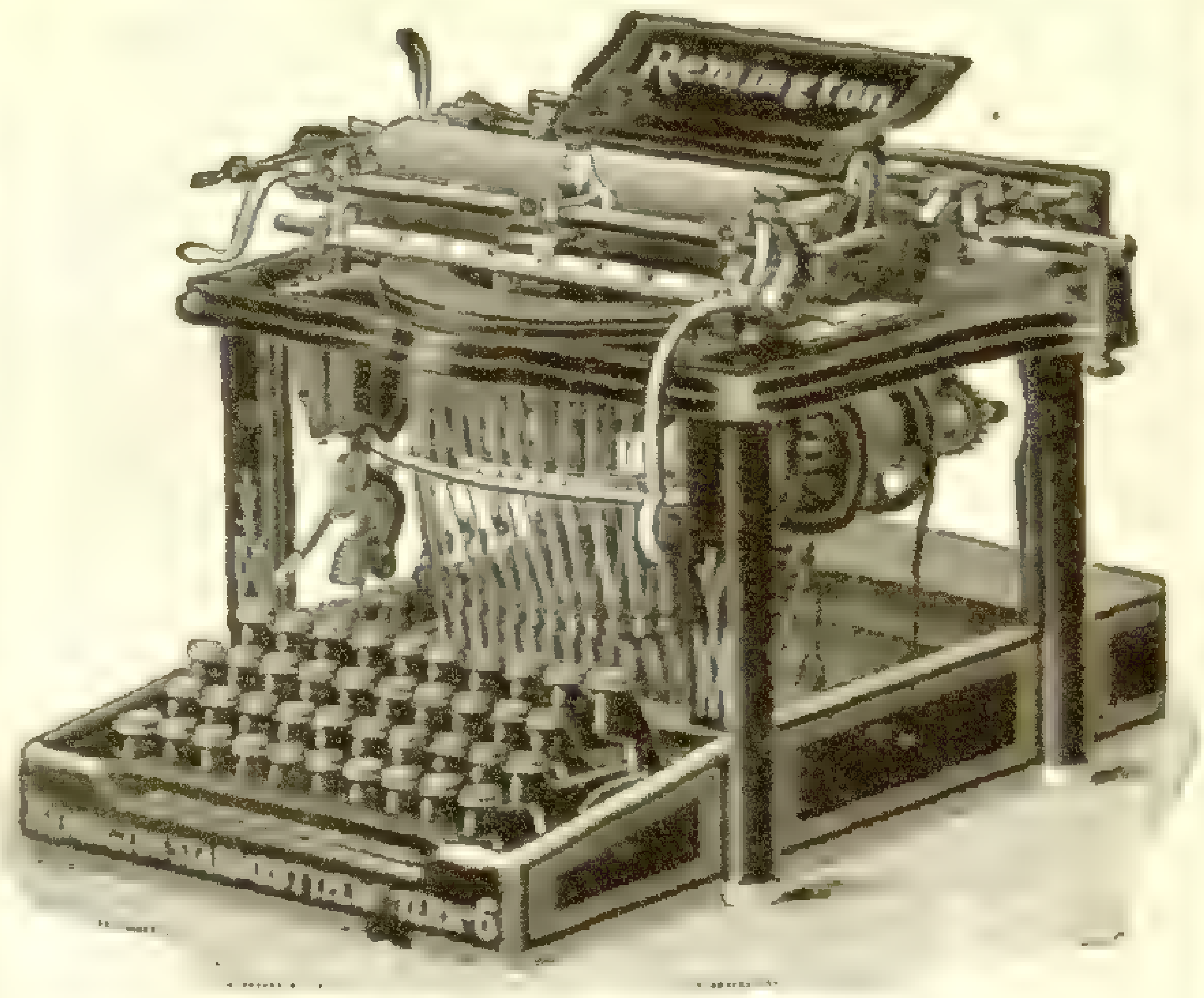

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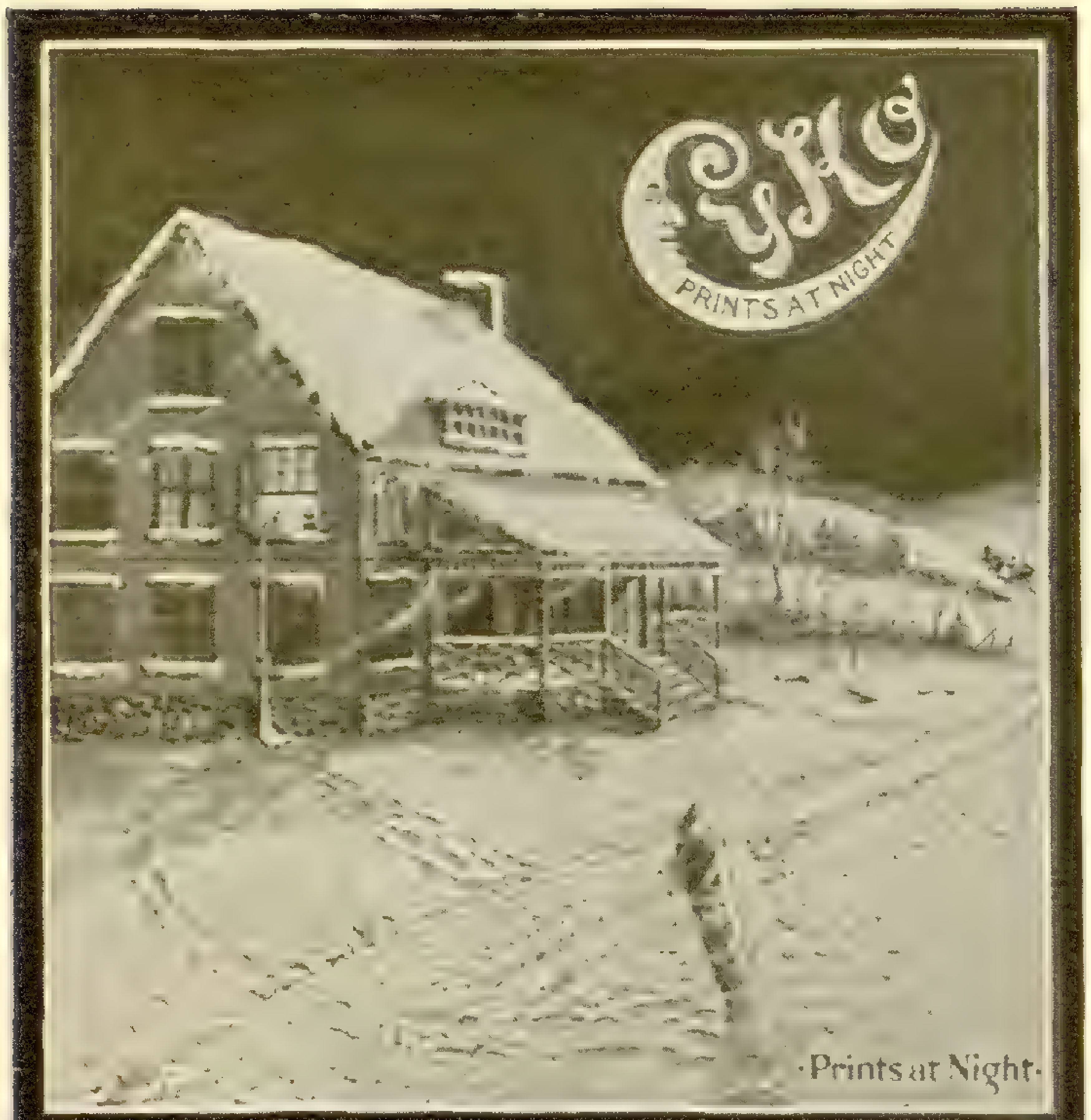

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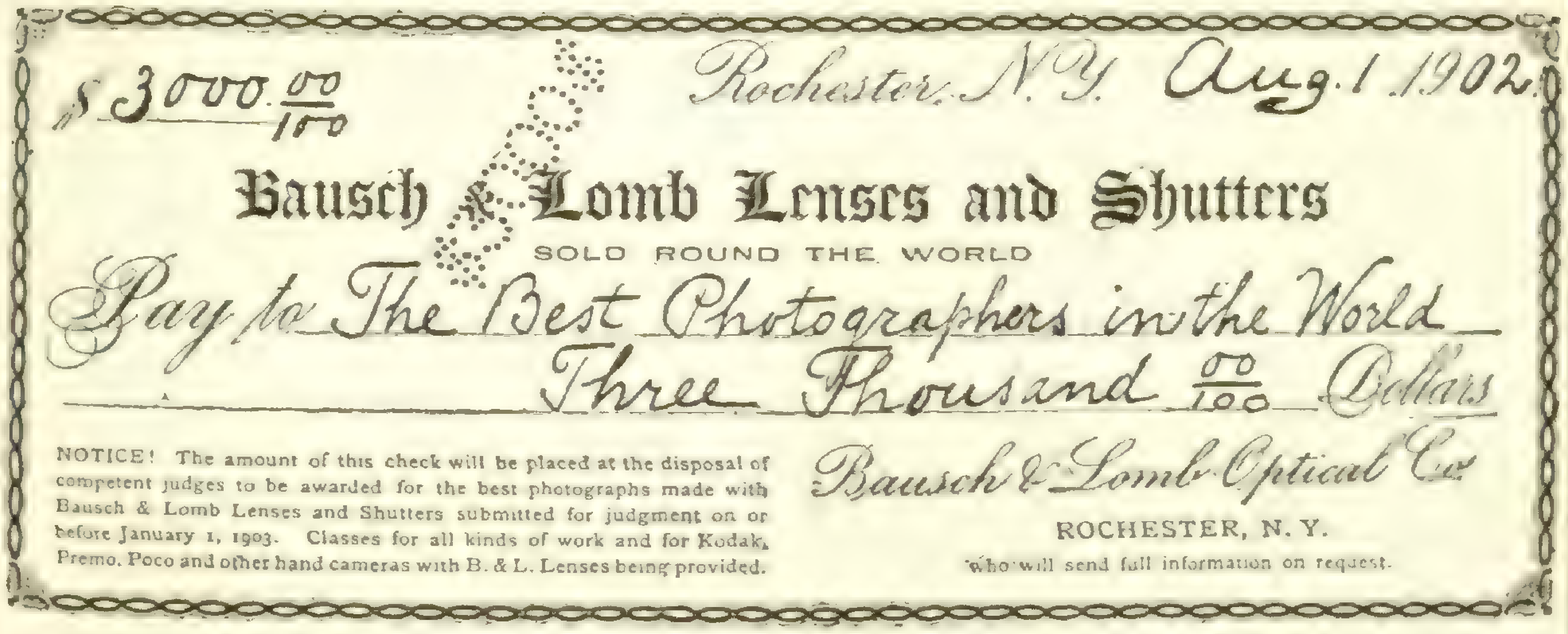

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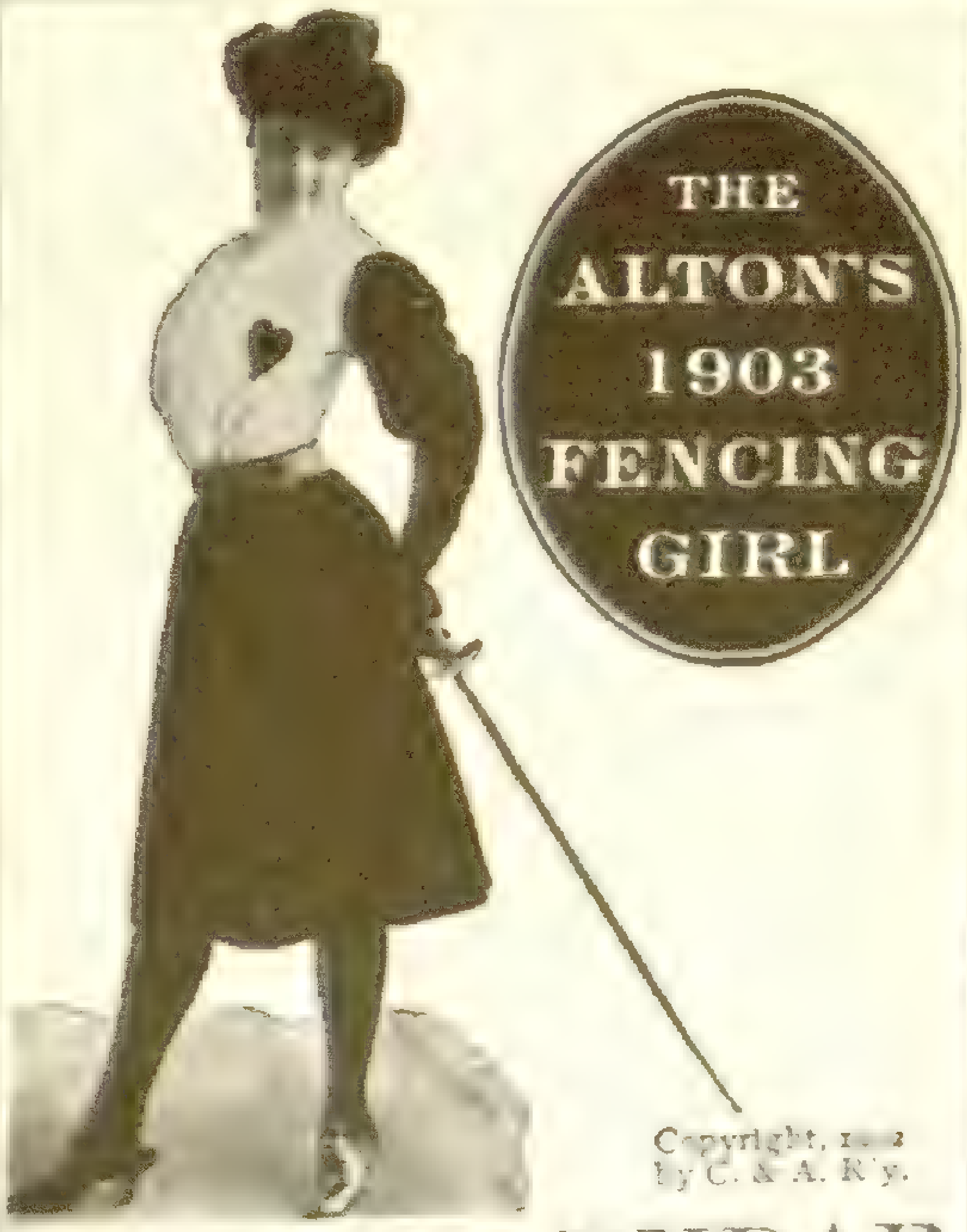
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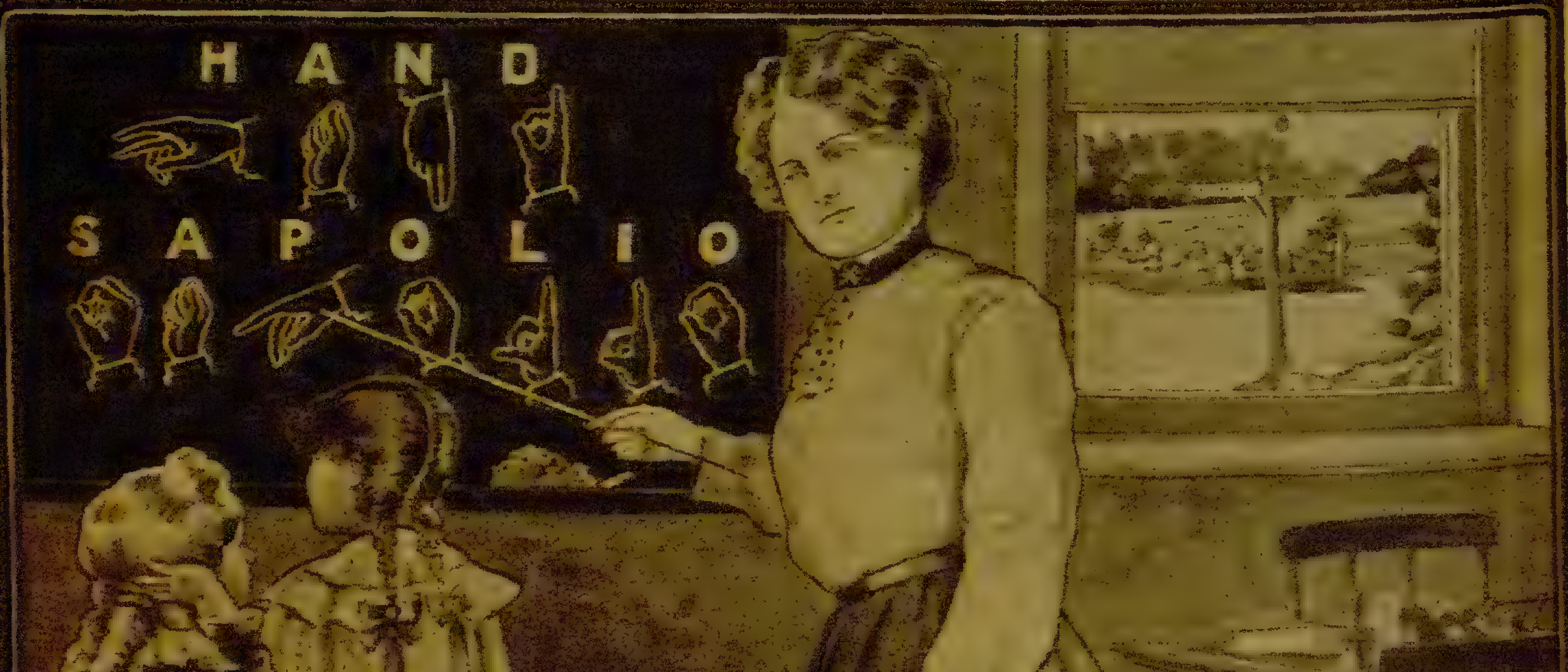

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VOLUME XXXV NUMBER 3

BOTANICAL GAZETTE

MARCH, 1903

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF HARVARD UNIVERSITY. LIV.

NEW OR PECULIAR NORTH AMERICAN HYPHOMYCETES. III.

ROLAND THAXTER.

(WITH PLATES IV AND V)

DURING a brief visit to Jamaica in the winter of 1890-91, the writer obtained, among numerous other interesting coprophilous forms, two peculiar genera of hyphomycetous fungi, both of which have been kept constantly in cultivation ever since. Although both these types are conspicuous, and appear to be widely distributed, no reference to either of them has been found in the literature, and it is assumed that they have been thus far overlooked.

The most striking and peculiar of these genera, to which I have given the name *Heterocephalum*, has the appearance of a very large Aspergillus, of a delicate orange-yellow color, from the head of which project numerous radiating spines or bristles, visible to the naked eye, the whole (*fig. 1*) recalling the conditions seen in Actiniceps. This resemblance is further strengthened from the fact that the spiniferous head is borne on a stalk which appears to be composed of numerous slender ascending hyphae, and at first sight one might be inclined to place the plant among the Hyalostilbeae. An examination of the early development of this fructification, however, makes it evident that it belongs to a quite different type, which appears to be, in some respects, unique among the Hyphomycetes.

The vegetative portion of the fungus consists of a copious mycelium of rather slender septate hyphae from which the fertile hypha usually arises as a lateral branch of relatively large diameter, which becomes abruptly differentiated. As this fertile hypha commences to rise above the substratum, a number of vegetative hyphae, or branches from them, grow toward it; and, as it elongates, apply themselves closely to its surface, growing upward as it develops and more or less completely corticating it, except in the region of its free extremity. When the fertile hypha has attained its full height the free tip, ceasing to elongate, becomes abruptly swollen, forming a head much as in Aspergillus (*fig. 2*), the whole surface of which soon becomes papillate with young sporiferous branches (*fig. 3*). The corticating hyphae meanwhile, being enabled to overtake the head, apply themselves closely to its surface and begin to push between the young sporiferous branches, by which they are soon more or less completely concealed. At the same time, also, they begin to branch more or less copiously, and the extremities of these branches, growing outward with the sporophores, extend rapidly beyond them (*fig. 8*), and eventually form the radiating septate bristles above referred to. Their development, however, is not confined to mere elongation; since, just below two or sometimes three of the lowest septa, they give rise to whorls of lateral branches, which, growing tangentially, by branching and intertwining eventually form an envelope like basket-work that incloses the sporogenous branches completely, and through which the bristle-like hyphae appear to project. The sporogenous hyphae in the meantime branch successively in an irregularly umbellate fashion, the branchlets becoming more numerous as the process is repeated. The basal cells and those of the main branches become greatly enlarged, closely compacted, and more or less adherent, so that they are with difficulty crushed apart; while the ultimate branchlets of the third or fourth order bear an irregular umbel of sporiferous branchlets, from the tips of which the minute oval spores are successively abjointed (*figs. 4–7*).

The head, which strongly suggests the pseudoperithecium, if it may so be termed, of the more highly differentiated species of

Gymnoascus, is thus a remarkable combination of two elements of independent origin. The conspicuous portion, which forms the main bulk of the head, consists of sterile elements derived from sterile hyphae in the mycelium, whose development runs parallel to that of the fertile hypha and whose function is evidently connected with spore dispersion. At maturity the bristles and other sterile elements of the head become echinulate through a more or less copious deposit (of calcic oxalate?) and adhere very readily to any object which touches them; while at the same time the whole head separates at a touch from its attachment to the stalk, carrying with it the mass of spores which, though not involved in mucus, are nevertheless adherent in a more or less compact mass. The successively abjointed spores do not appear to remain united in chains, though two or three may often be seen thus adherent, and, judging from the dense contents of the compacted and firmly adherent sporogenous branches, it seems not improbable that they may continue to be abjointed even after the head has become separated from the stalk which bears it.

The spores germinate readily, and the fungus fruits abundantly on nutrient agar of various kinds, the fructifications being usually more or less gregarious, often so much so that adjacent heads adhere to one another over a considerable area and may be lifted in a continuous mat.

Although this fungus has been under cultivation for twelve years on various substrata, and under varied conditions, no ascigerous fructification has as yet made its appearance. That it belongs among the Plectascineae nevertheless, and that an ascigerous condition of this nature will eventually be found, can hardly be doubted. The same fungus has been received from another source within the past year, having fruited spontaneously in transit, on some goat's dung, in a vial hermetically sealed with wax, which was sent to my assistant, Mr. A. F. Blakeslee, from the Philippine Islands. It may thus be assumed that the plant has a wide distribution in the tropics from its independent occurrence in antipodal regions.

The second form, which I have called *Cephaliophora*, made its appearance on a bit of mongoose dung picked up in a ravine near Kingston. It forms at first a cottony mycelium composed of septate branching hyphae of very rapid growth, which soon collapse more or less completely, sending up at intervals short branchlets which become sporophores, and under a hand lens appear to rise directly from the substratum. These sporophores consist of short, broadly clavate branches, the distal portion swollen with variable abruptness, and from the surface of the more or less distinctly differentiated head thus formed the spores arise directly as in Oedocephalum. The spores, which are fawn colored to pale chocolate-brown in the mass, are quite unlike those of other genera of this type in being multiseptate, thick-walled, and subcylindrical. The septa are transverse and commonly three in number, but vary from two to rarely as many as six. The basal cell is never functional and always colorless, and others of the cells, especially the terminal ones, are often empty at maturity, the contents becoming concentrated in the remaining segments. The mature spores have very thick walls and are able to retain their vitality air-dry for more than a year, germinating readily in water, or on nutrients, in the ordinary fashion.

Like the first type described above, this fungus has been in constant cultivation for twelve years in my laboratory without showing any signs of the production of an ascigerous condition. The same species has been obtained and cultivated, for periods ranging from two to six years, from Liberia, Africa, from Java, and from China, under conditions which leave no doubt of its origin from these localities, so that it may be assumed to be a common form of wide distribution throughout the tropics.

A second and closely allied species of the same genus was also obtained on material sent from Porto Rico, and although it was at first believed to be a mere variety of the first, its differences, after five years of cultivation, still remain so constant that its separation seems warranted. Its spores are differently shaped, and normally once, less often twice, septate, the terminal cell being relatively large and usually the only functional segment. Its habit of growth in tubes is also less luxuriant, the sporiferous hyphae forming a stringy coating on the agar, usually more or less characteristic, while the color of the spore mass is distinctly more rufous.

HETEROCEPHALUM, nov. gen.—Vegetative mycelium consisting of fine, septate, branching, colorless hyphae growing on and in the substratum. Fertile hyphae abruptly differentiated, erect, stout, swelling distally to form a well-distinguished terminal head, the whole surface of which gives rise to sporophores several times subumbellately branched, the ultimate branchlets abjointing successively continuous hyaline spores. The fertile hypha corticated by sterile hyphae which grow upward with it, eventually forming a special envelope about the sporiferous portion of the head.

Heterocephalum aurantiacum, nov. sp.—Color pale clear orange-yellow, sometimes almost salmon colored. Sporogenous hyphae four to five times successively subumbellately branched, the irregularly bottle-shaped sporophores borne in terminal groups of about six or eight from branchlets of the third or fourth order. Spores minute, oval to oblong, somewhat irregular in size and outline. Corticating hyphae about six to ten in number, giving rise to numerous (about twenty-five to fifty, more or less) straight, rigid, bristle-like, tapering, septate branches radiating in all directions from the head, often terminating in a slight, rather abrupt, enlargement, and producing, in whorls just above their two lower septa, several lateral branchlets growing tangentially, branching and intertwining to form a spherical envelope, like basket-work, about the fertile head and coherent spore mass within; the radiating setae and their branches becoming more or less prominently echinulate at maturity. Spores about $3.5 \times 3\mu$. Fertile hyphae 1.5–3^{mm} high by 8–14μ in diameter. Radiating setae about 600–1500μ in length. Diameter of head, including spore mass, 300–375μ; including envelope, 500–750μ.

On dung of toad, Kingston, Jamaica (1890–91); on goat dung, Philippine Islands.

CEPHALIOPHORA, nov. gen.—Vegetative hyphae copious, branching, septate, colorless. Sporophores arising as short branches from the hyphae, which become more or less abruptly enlarged distally to form a variably differentiated head, from the surface of which the spores are produced. Spores once to several times transversely septate, becoming brownish, the sterile basal segment narrowed to form a more or less distinct pedicellate attachment.

Cephaliophora tropica, nov. sp.—Sporophores very variable, the heads nearly spherical or more or less elongated, short-stalked or almost sessile. Spores hyaline, becoming fawn- to pale chocolate-brown in the mass, translucent, darker at the septa, two- to five-septate (normally three-septate), subcylindrical; the sterile basal cell tapering to a well-marked pedicellate attachment. Spores, average about $35 \times 16\mu$, maximum about 50×19–20μ. Diameter of head, average about 28–35μ. Average length of fertile branch, including head, 60–75μ.

On mongoose dung, Kingston, Jamaica; on ass dung, Liberia; on rat dung, Java; on mouse dung, China.

Cephaliophora irregularis, nov. sp.—Similar to the last; the spores in the mass more reddish-brown, the habit of growth somewhat different. Spores very variable in form and size, normally once, sometimes twice, septate; the terminal cell only (as a rule) fertile, usually broadly rounded, often broadened, and not infrequently bilobed. Average spore measurements 25–$30 \times 18\mu$, maximum about $36 \times 30\mu$.

On mouse dung, Porto Rico.

HARVARD UNIVERSITY.

EXPLANATION OF PLATES IV AND V.

The figures were drawn with camera lucida and reduced in reproduction. The approximate magnifications are as follows: *fig. 1* × 60; *figs. 2–3, 11–15, 17–19* × 390; *figs. 4–7, 10, 16* × 860; *figs. 8–9* × 100.

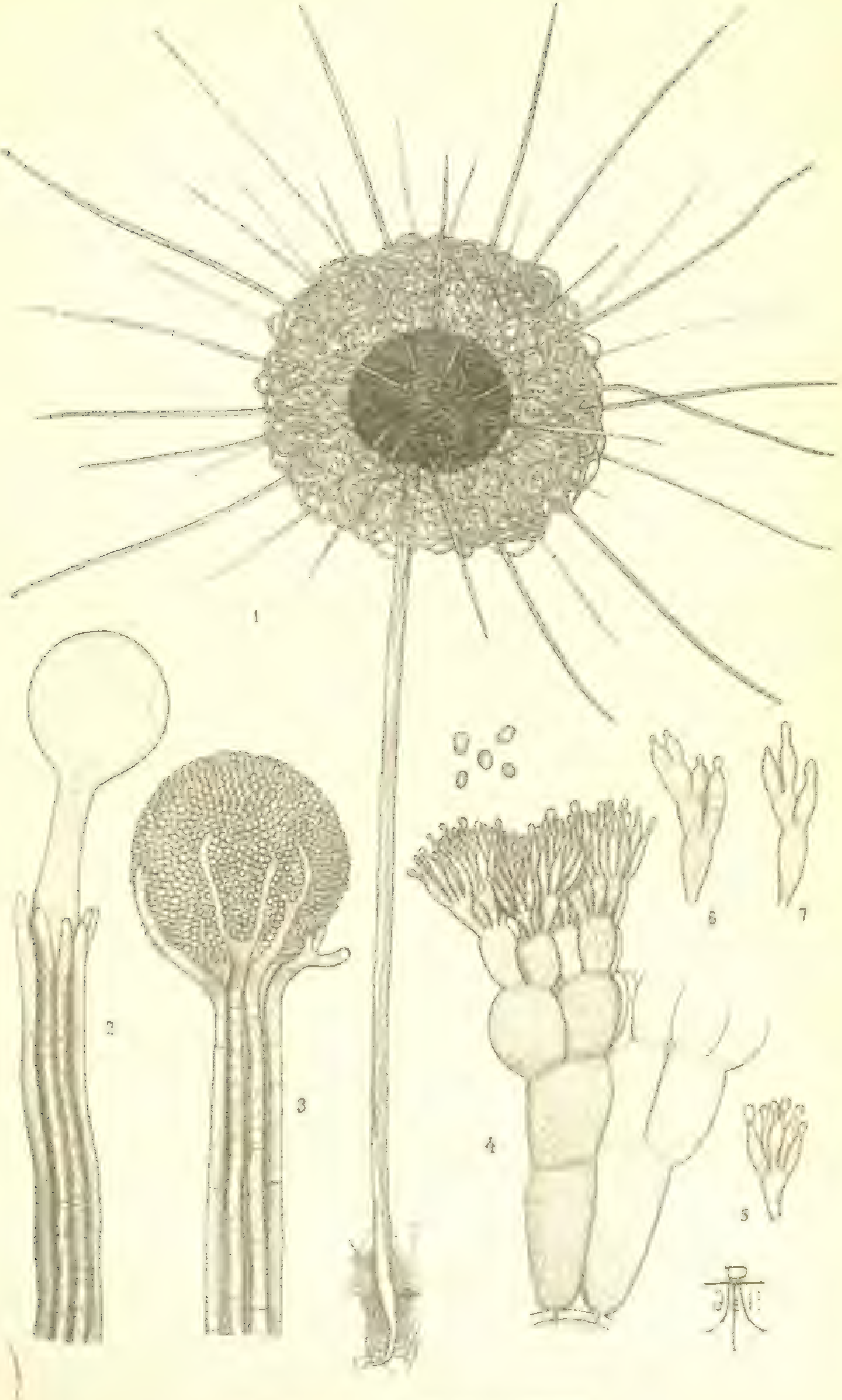
FIGS. 1–10. *Heterocephalum aurantiacum.*

FIG. 1. General habit; the dark central portion of the head represents the spore mass surrounding the sporophores.

FIG. 2. Terminal portion of a fertile hypha, its tip enlarged to form the fertile head, which has not yet been overtaken by the corticating hyphae.

FIG. 3. Fertile head covered with young sporogenous branches, among which the branching tips of the corticating hyphae are beginning to push.

FIG. 4. Small portion of fertile head showing sporogenous branches and their origin; above, four spores.



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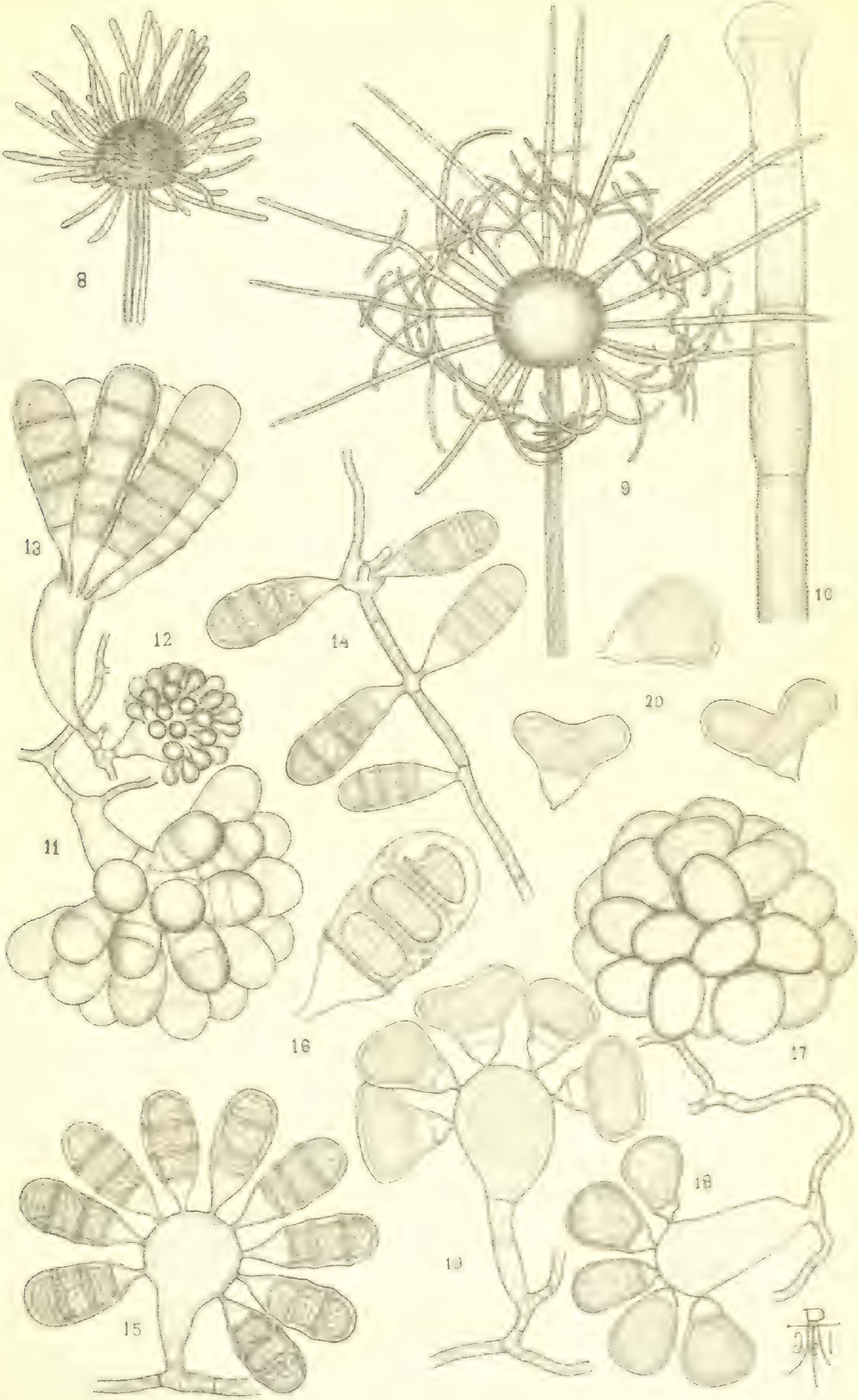
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THAXTER on HYPHOMYCETES:

FIG. 5. Branch of the fourth order bearing tuft of sporiferous branchlets.

FIGS. 6–7. Young sporogenous branches from which branchlets of the third and fourth order are budding.

FIG. 8. Young fertile head, the subclavate branches of the corticating hyphae projecting from among the young sporogenous branches.

FIG. 9. A more mature condition, in which these branches are becoming bristle-like and are giving rise to the whorls of lateral branchlets which form the sterile envelope shown in *fig. 1*.

FIG. 10. Tip of one of the mature setae, showing echinulation.

FIGS. 11–16. *Cephaliophora tropica.*

FIG. 11. Normal sporiferous head with spores *in situ.*

FIG. 12. Young head with spores just developing.

FIG. 13. Abnormally elongate head with unusually long 4–5-septate spores.

FIG. 14. Abnormal development of spores directly from the hyphae.

Fig. 15. Normal head seen in optical section.

FIG. 16. Normal fully mature spore.

FIGS. 17–20. *Cephaliophora irregularis.*

FIG. 17. Head with rather broad spores.

FIG. 18. Head in optical section showing normal spores.

FIG. 19. Head in optical section with broad biseptate spores.

FIG. 20. Three spores.

CHEMICAL STIMULATION AND THE EVOLUTION OF CARBON DIOXID.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XLIV.

EDWIN BINGHAM COPELAND.

[*Concluded from p. 98.*]

As has already been noted, the interpretation of my results with metallic poisons is uncertain. When the most of the experiments were performed it was without a suspicion that the CO_2 evolved from the plants could be anything but an immediate product of respiration. The results were presented in that light to the Botanists of the Central States at their meeting of December 1901. Since that time I have shown, and will present the evidence in the following tables, that these metallic salts can drive CO_2 from solutions of such salts as are in the cell sap. In any experiment, then, it may come directly from the proteid or from the sap, and it probably comes from both.

Before the experiment began each subject of experiment was left over night in its bottle, with a current of CO_2-free air passing through it *as rapidly as during the experiment*. The CO_2 evolved is expressed in cubic centimeters of normal acid for each hour. The data of the first experiment, except the temperature, are copied in full from my notebook, to illustrate the nature of the record. The poison was applied by opening the bottle and dropping in with a pipette enough of a concentrated solution to give the desired strength. The bottle is open very few seconds. I have satisfied myself repeatedly, by putting in water in the same way, that this introduces no error. The bottle was at once shaken thoroughly to insure the equal distribution of the poison. In each experiment except XXXVII Elodea was used.

The acceleration is rather great, considering the dilution; this is possibly due to the fact that the plants had been unusually long in the laboratory, and were respiring very slowly. The

TABLE II.

January 3. To test $\frac{M}{4000}$ $ZnSO_4$ 100^cc baryta water = 12.32^c $\frac{M}{100}$ acid.

TIME	EXPERIMENT		CONTROL	
	Titre	cc. N. per hour	Titre	cc. N. per hour
10:16–11:16	.....	.....	12.20	0.012
11:16 12:16	12.20	0.012	12.20	0.012
12:16– 1:52	12.15	0.011	12.18	0.009
1:52 9.5^{cc} $\frac{M}{100}$	$ZnSO_4$ put	into 370^{cc} in	exp. bottle,	making $\frac{M}{4000}$.
1:52– 3:04	12.05	0.022	12.20	0.010
3:04– 4:04	12.10	0.022	12.20	0.012
4:04 5:10	12.10	0.020	12.20	0.011
5:10– 7:10	11.90	0.021	12.12	0.010
7:10 9:30	11.85	0.020	12.10	0.009
9:30–10:54 (13.4 hours)	10.05	0.017	10.85	0.011
10:54– 2:36	11.70	0.018	12.00	0.009
2:36 Control	given same	dose of	$ZnSO_4$.	
2:36– 5:00	11.80	0.023	11.85	0.020

great variation in the length of the intervals between the tests is a much more severe test of my method and apparatus than making observations regularly, say every hour or two hours, would be.

The next experiment shows a parallel use of double-distilled and tap water; the evolution of CO_2 is hastened slightly more from the latter.

TABLE III.

January 6. To test $\frac{M}{8000}$ $ZnSO_4$. Double-distilled water in experiment bottle, tap water in control. Result in cc. N. per hour.

Time	Experiment	Control
9:33–10:39	0.015	0.020
10:39–11:51	0.022	0.022
11:51 $\frac{M}{8000}$ $ZnSO_4$	in both	bottles.
11:51–1:51	0.024	0.034
1:51–4:51	0.025	0.030
4:51–7:45	0.025	0.032
7:45–9:47 (14 hours)	0.020	0.023

In the next experiment the difference between the tap water and the double-distilled water is doubtful. When it happened I ascribed the greater evolution of CO_2 from the former to imperfect distribution of the $ZnSO_4$.

TABLE IV.

January 10. To test $\frac{M}{16000}$ $ZnSO_4$. Double-distilled water in experiment bottle, tap water in control. Results in cc. N. per hour.

Time	Experiment	Control
10:37–12:38	0.027	0.027
12:38– 2:08	0.027	0.027
2:08– 3:26	0.027	0.023
3:26 $\frac{M}{16000}$ $ZnSO_4$ in both bottles.		
3:26– 4:50	0.023	0.043
4:50– 5:50	0.027	0.035
5:50– 8:33	0.027	0.030
8:33–10:03	0.021	0.027
10:03–12:03 (14 hours)	0.028	0.028

The conclusion from this experiment is that $\frac{M}{16000}$ $ZnSO_4$ exerts no appreciable stimulation.

We shall now take up the experiments with more concentrated $ZnSO_4$.

TABLE V.

December 30. Test of $\frac{M}{1143}$ $ZnSO_4$.

Time	Experiment	Control
11:40–12:40	0.025	0.023
12:40– 1:46	0.027	0.027
1:46– 2:46	0.025	0.025
2:46 $\frac{M}{1143}$ $ZnSO_4$ in exp. bottle.		
2:46– 3:46	0.040	0.025
3:46– 4:46	0.038	0.025
4:46– 5:46	0.040	0.025
5:46– 7:46	0.035	0.025

In the remaining experiments the control will be omitted from the report, when it is a mere list of uniform figures.

TABLE VI.

December 17. Test of $\frac{M}{100}$ $ZnSO_4$.

Time	Experiment	Remarks
11 : 52–1 : 52	0.042	
1 : 52–2 : 52	0.040	
2 : 52 $\frac{M}{100}$	$ZnSO_4$ in	exp. bottle.
2 : 52–3 : 52	0.430	The water was poured from both bottles and boiled, and the CO_2 collected; the excess from the exp. bottle over that from the control was
	0.320	☜
Total CO_2 in first hour	0.750	A similar treatment another hour with fresh tap water showed
Total CO_2, second hour	0.665	☜
Total CO_2, third hour	0.550	

After the third hour the plants were put into water, and were alive but unsound the next morning.

TABLE VII.

December 18. Test of $\frac{M}{50}$ $ZnSO_4$.

Time	Experiment	Remarks
9 : 35–11 : 35	0.033	
11 : 35–12 : 35	0.030	
12 : 35– 2 : 53	0.033	
2 : 53 $\frac{M}{50}$	$ZnSO_4$ in	exp. bottle.
2 : 53– 3 : 53	0.490	The CO_2 was driven off as in the last exp.
Excess from exp.	0.300	
Total CO_2	0.790	

The preceding experiments were all performed at 19°–21° C. The temperature for the next one was 28°–29° C.

TABLE VIII.

December 16. Test of $\frac{M}{50}$ $ZnSO_4$.

Time	Experiment	Remarks
9 : 30–11 : 42	0.045	
11 : 42– 1 : 42	0.045	
1 : 42 $\frac{M}{50}$	$ZnSO_4$ in	exp. bottle.
1 : 42– 2 : 42	1.000	The CO_2 driven from both bottles.
Excess CO_2 from exp.	0.160	
Total CO_2	1.160	

In the experiments with $\frac{M}{50}$, $\frac{M}{100}$, and $\frac{M}{200}$ it was 10–15 minutes before the precipitation of $BaCO_3$ was apparent; then it became very rapid at once.

The bare end-results of some experiments at higher temperatures will be sufficient.

TABLE IX.

December 13. Test of $\frac{M}{100}$ $ZnSO_4$ at 37.5° C.

Time	Experiment	Remarks
2:12–3:12	0.060	
3:12	$\frac{M}{100}$ $ZnSO_4$ in	exp. bottle.
3:12–4:12	0.800	Including excess CO_2 from exp. bottle
Total CO_2	0.925	

The plants were put into water and remained alive.

TABLE X.

December 12. Test of $\frac{M}{200}$ $ZnSO_4$ at 37° C.

Time	Experiment
10:05–2:11	0.088
2:11	$\frac{M}{200}$ $ZnSO_4$ in exp. bottle.
2:11–3:11	0.815
Total CO_2	1.315

TABLE XI.

December 9. Test of $\frac{M}{500}$ $ZnSO_4$ at 39.5° C.

Time	Experiment
2:05–4:05	0.087
4:05	$\frac{M}{500}$ $ZnSO_4$ in exp. bottle.
4:05–5:00	0.743
5:00–6:30	0.627

TABLE XII.

December 4. Test of $\frac{M}{1000}$ $ZnSO_4$ at 36° C.

Time	Experiment
3:41–5:32	0.109
8:10 $\frac{M}{1000}$	$ZnSO_4$ in exp. bottle.
8:10–10:10	0.207

TABLE XIII.

Temp.	Dilution	Increment
28° C.	50	2480
19	50	2290
19	100	1775
37.5	100	1440
37	200	1390
39.5	500	800
36	1000	90
19	1143	60
19	4000	100
19	8000	30
19	16000	0

If the results of these experiments with zinc are roughly summed up for comparison, it will be seen that the high acceleration by $\frac{M}{4000}$ presents the only exception to the rule that the more zinc applied, the more CO_2 is driven off. The figures here are the per cent. increment of CO_2 evolved after poisoning. The numerator (M) of the fractions is omitted.

The experiments on the influence of copper will be taken up next. The temperature in all of these was in the neighborhood of 20° C.

TABLE XIV.

January 20. Test of $\frac{M}{80000}$ $CuSO_4$.

Time	Experiment	Control
10:08–3:55	0.030	
3:55 $\frac{M}{80000}$	$CuSO_4$ in exp.	bottle.
3:55–5:01	0.030	0.030
5:01–7:16	0.027	0.027
7:35	Same dose given	to control.
7:35–8:36	0.031	0.030

$\frac{M}{80000}$ $CuSO_4$ is then without demonstrable influence on the respiration.

TABLE XV.

January 15. Test of $\frac{M}{40000}$ $CuSO_4$.

Time	Experiment
8 : 45–10 : 27	0.029
10 : 27–12 : 27	0.032
12 - 27– 2 : 15	0.027
2 : 15 $\frac{M}{40000}$ $CuSO_4$	in exp. bottle
2 : 15– 3 : 15	0.039
3 : 15– 5 : 27	0.049
5 : 27–11 : 27	0.051
11 : 27–10 : 32	0.044
10 : 32– 5 : 02	0.042
5 : 02– 9 : 38	0.044

TABLE XVI.

January 13. Test of $\frac{M}{20000}$ $CuSO_4$.

Time	Experiment
11 : 46–1 : 16	0.041
1 : 16–2 : 28	0.042
2 : 28–3 : 46	0.043
3 : 46–4 : 52	0.042
4 : 52 $\frac{M}{20000}$ $CuSO_4$	in exp. bottle.
4 : 52–5 : 52	0.073
5 : 52–7 : 52	0.067
7 : 52–9 : 52	0.072
9 : 52–9 : 52(12 hrs.)	0.062

The record in table XV is given for the entire period of observation. It should be said that from most of the tables both ends have been omitted, the published record covering the time more immediately before and after poisoning.

Table XVI shows less CO_2 was evolved toward the end of the experiment, but the material remained alive.

The plants were left in water over night; but few cells were alive the next morning.

TABLE XVII.

December 19. Test of $\frac{M}{10000}$ $CuSO_4$.

Time	Experiment
11 : 38–2 : 44	0.034
2 : 44 $\frac{M}{10000}$ $CuSO_4$	in exp. bottle.
2 : 44–3 : 44	0.100
Exc. CO_2 in water of exp. bottle	0.010
Total CO_2	0.110

TABLE XVIII.

December 20. Test of $\frac{M}{5000}$ and $\frac{M}{2000}$ $CuSO_4$, there being no control.

Time	Experiment A	Experiment B
10:00–2:12	0.040	0.038
2:12 $\frac{M}{5000}$ $CuSO_4$	in exp. A bottle.	$\frac{M}{2000}$ in exp. B bottle.
2:12–3:12	0.275	0.335
Total CO_2	0.320	0.435

The CO_2 was driven from both bottles, and the estimated content at the beginning of the hour subtracted; the remainder added to that found by titration.

Both bottles were treated in the same way another hour, with practically the same result. After the first hour most cells were alive in both bottles; but after two hours the plants of exp. B were practically dead.

The result of this experiment made it appear exceedingly probable that CO_2 was evolved after death under the influence of copper. The next two experiments show that this is the case.

TABLE XIX.

December 26. Test of $\frac{M}{2000}$ $CuSO_4$.

Plants boiled for twenty minutes in distilled water; then cooled and washed until no CO_2 came off.

Time		Experiment
3:39–4:51		0.000
4:51	$\frac{M}{2000}$ $CuSO_4$	in bottle.
4:51–5:57		0.082
5:57–7:39		0.029
4:51–7:39 (total CO_2)		0.140

TABLE XX.

January 9. Test of $\frac{M}{1167}$ $CuSO_4$.

This material was boiled twice in double-distilled water.

Time		Experiment
5:27–6:27		0.007
6:27	$\frac{M}{1167}$ $CuSO_4$	in exp. bottle.
6:27–7:33		0.429

This raised the question as to whether or not Zn might act in the same way on boiled Elodea. Experiment shows that it does.

These results were construed as proving that dead "protoplasm" could be caused to evolve CO_2 by the action of Cu and Zn. As a matter of curiosity I made a similar experiment, using $\frac{M}{1000}$ $CuSO_4$ on peptone (in distilled water); no CO_2, or at most a trace, was evolved.

TABLE XXI.

December 28. Test of $\frac{M}{100}$ $ZnSO_4$. The material was boiled under suction, and washed until no CO_2 came off.

Time		Experiment
8:53–9:53		0.000
10:04	$\frac{M}{100}$ $ZnSO_4$	in bottle.
10:04–11:04		0.020
11:04–12:22 (12.3 hrs.)		0.004
Total CO_2 evolved		0.070

The results of the experiments with copper on live plants are summarized here, in the form explained in connection with the similar table on zinc:

TABLE XXII.

Dilution	Acceleration, Per Cent	Dilution	Acceleration, Per Cent
2000	1045	20000	52
5000	700	40000	47
10000	224	80000	0

The next table shows the action of several concentrations of mercury.

TABLE XXIII.

January 23. Tests of $HgCl_2$.

Time	Experiment	Control
10:28–2:04	0.029	0.033
2:04 $\frac{M}{160000}$	$HgCl_2$ in exp. bottle.	
2:04–7:46	0.035	0.027
7:46 $\frac{M}{80000}$	$HgCl_2$ in control bottle.	
7:46–11:34	0.037	0.039
11:34–11:16 (11.7 hrs.)	0.027	0.032
11:16 A. M. Exp. alive	and sound. Control mostly alive, unsound.	
1:58 P. M. $\frac{M}{10000}$	$HgCl_2$ in exp. bottle.	$\frac{M}{1000}$ in control bottle.
1:58–2:58	0.235	0.685
2:58 Exp. culture	practically dead.	Control dead.

The solutions were poured off to determine the CO_2 in them, and to investigate the post-mortal "respiration" similar solutions made up with tap water were put on the dead Elodea in the bottles. This was followed by practically the same evolution of CO_2 as when the solutions were first applied; which seemed to show that the substance from which the CO_2 was driven off was not exhausted enough to interfere with the reaction. In this connection it was assumed that the evolution of CO_2 gradually slackened under the influence of an individual dose of poison because the mercury entered into combination and ceased to act. The material was then devoted to a determination of how much CO_2 might be driven from it by an indefinitely repeated renewal of the dose of $HgCl_2$. When this had gone on long enough to become monotonous, I varied it by applying the same amount of $HgCl_2$ in less water, making it more concentrated. *Less* CO_2 was evolved. I then put 700^{cc} of tap water, without Elodea, in each bottle, and gave it the dose which the Elodea and water had been receiving, with the same result. The $HgCl_2$ applied was:

Exp. bottle, $0.7^{cc}\ \frac{M}{10}$ Control, $7.0^{cc}\ \frac{M}{10}$.

Total CO_2 evolved in 24 hrs. - 0.535^{cc} N. - 2.370^{cc} Normal.
The CO_2 which can be washed from seven hundred cubic centimeters of tap (lake) water varies, but is less than 0.310^{cc} N. - - 0.310^{cc} N., leaving as result of the $HgCl_2$ at least - 0.225^{cc} N. - 2.060^{cc} N., which is more in both cases than the equivalent of the $HgCl_2$ applied.

Evidently no conclusions can be drawn as to the respiration of Elodea, dead or alive, from work with Hg in the presence of tap water. I therefore washed a lot of Elodea very thoroughly in double distilled water for the next experiment.

TABLE XXIV.

March 7. Tests of $HgCl_2$.

Time	Experiment	Control
11:09–3:39	0.070	0.059
3:39 $\frac{M}{80000}$	$HgCl_2$ in exp. bottle.	
3:39–4:39	0.095	0.058
4:39–6:33	0.076	0.059
6:33 $\frac{M}{1000}$	$HgCl_2$ in exp. bottle. Plants removed from control, and air run through water to wash it.	
6:33–10:24 (15.85 hrs.)	0.530	(Total CO_2), 0.110^{cc} N
10:24–11:37	. . . . .	(Total) 0.012
11:38 $\frac{M}{80000}$	$HgCl_2$ in control bottle.	
11:38–12:40	. . . . .	(Total) 0.060
12:40 $\frac{M}{1000}$	$HgCl_2$ in control bottle.	
12:40–8:00		(Total) 0.110^{cc} N

The last part of this experiment, with the water in which the control plants had stood, shows that CO_2 is driven from substances, presumably carbonates, as of lime, passed from the plants into the water. The evolution of CO_2 caused by $\frac{M}{1000}$ $HgCl_2$ was less excessive than when the plants were present; this I do not ascribe to a reaction with the proteid, but rather to the presence of the cell sap. The difference is doubtless because of the limited amount of carbonates which had passed from the plants to the water outside. The experiment as a whole shows that no necessarily valid conclusions can be drawn as to the stimulation of the respiration of Elodea with $HgCl_2$, even using the purest distilled water.

The significance of the observations on the influence of Zn and Cu was immediately in doubt. Acting on the suggestion derived from the similar effect of $HgCl_2$ on tap water and on distilled water after the Elodea had stood in it, I used tap water with Zn and Cu, so that the reaction, if any, should be more considerable.

TABLE XXV.

March 9. Action of Zn and Cu on tap water.

Time	Experiment	Control
12:23–1:23	0.005	0.010
1:23 $\frac{M}{1000}$ $ZnSO_4$ in exp. bottle. $\frac{M}{10000}$ $CuSO_4$ in con.		
1:23–2:25	0.150	0.052
2:25 Exp. stopped. $\frac{M}{1000}$ $CuSO_4$ in control bottle.		
2:25–3:25		0.645

These results approach what I got with the same "stimulants" with Elodea in the water.

A test of the apparent action of $AgNO_3$ on the respiration was followed immediately by one with tap water.

TABLE XXVI.

May 1. Test of $AgNO_3$.

Time	Experiment
8:44–1:45	0.042
1:45 $\frac{M}{40000}$ $AgNO_3$ in exp. bottle.	
1:45–2:45	0.130
2:45–3:45	0.095
Tap water then used, with out any plants.	
5:34–7:04	0.037
7:04 $\frac{N}{10000}$ $AgNO_3$ in bottle	
7:04–8:04	0.080

This is just near enough to the result with Elodea to rob the latter result of significance as to the respiration.

In another test of the action of $AgNO_3$ on tap water, the water was boiled and cooled with a stream of CO_2-free air passing through it. It was poured into another bottle and then dosed with $AgNO_3$, which drove off only a trace of CO_2. The difference between this and previous experiments with boiled water must have been that the precipitated carbonate was gotten rid of by changing bottles.

$NiCl_2$ was tested similarly to $AgNO_3$.

TABLE XXVII.

May 13. Test of $NiCl_2$. The experiment bottle contains Elodea in 400 cc "Neptune" (a triple-distilled commercial water). The control bottle contains 400 cc tap water.

Time	Experiment	Control
11:05–12:59	0.027	0.003
12:59 $\frac{M}{1000}$	$NiCl_2$ in both	bottles.
12:59– 2:59	0.035	0.026
2:59– 6:23	0.034	0.018

The acceleration during the first two hours is decidedly more considerable with the tap water than with the Elodea. The rather rapid decrease, while the Elodea is practically constant, might indicate that the effect on the latter is on the proteid, but does not necessarily point that way, as it might merely be because the salts in the sap are not acted on at once.

I deemed it not worth while to test the action of some other poisons on Elodea, since, as table XXVIII shows, they all drive CO_2 from tap water.

I have been assuming that the cell sap contains salts like those in the tap water, from which CO_2 can be driven by the poisons applied. This cannot well be doubted; still it seemed desirable to prove it, if possible, by direct experiment. For this purpose I crushed a mass of Elodea from which I should say the CO_2 evolved at the temperature of the experiment could not possibly have been in excess of 0.060 cc N per hour. The sap was squeezed out and the material washed and squeezed again. Of course the plants were most thoroughly washed with distilled water before crushing. The sap was then diluted to 150 cc, and placed in the "control" bottle, while the

TABLE XXVIII.

May 2 and 3. The subject of each of these tests was 400 cc tap water.

Time	Experiment
2:36– 6:06	0.003
6:06 $\frac{M}{100}$	$CoCl_2$ in bottle.
6:06– 7:21	0.144
8:10– 9:16	0.000
9:16 $\frac{N}{100}$	HCl in bottle.
9:16–10:22	1.677
10:18–12:52	0.018
12:52 $\frac{M}{100}$	$Pb(NO_3)_2$ in bottle.
12:52– 2:20	0.776
6:40– 8:20	0.003
8:20 $\frac{M}{1000}$	$Cd(NO_3)_2$ in bottle.
8:20– 9:26	0.341

"experiment" bottle contained rather less Elodea, uninjured, in 150^{cc} distilled water. The sap was extracted and *filtered* during the evening, and evolved a great deal of CO_2 during the night. The record begins the next morning.

This shows an acceleration of the evolution of CO_2 from the sap, caused by the cadmium salt; also from the sound plants, but not quite as much during the one hour of the action of the cadmium.

TABLE XXIX.

May 23. "Respiration" by sap.

Time	Experiment	Control
9:40–1:22	0.040	0.261
A slight precipitate in the sap caused me to refilter it.		
1:40–6:34	0.046	0.155
6:34	$\frac{M}{1000}$ $Cd(NO_3)_2$ in both bottles.	
6:34–7:34	0.085	0.310

But the most remarkable thing about this experiment was the great evolution of CO_2 from the filtrate. The filtration seemed thorough both times, and after the second no precipitate could be detected before the cadmium was put in; afterward a very slight one was formed. The filtrate was colored and opalescent from the start. It is as impossible to treat the influence of cadmium on the evolution of CO_2 from the sap as depending on the carbonates in the latter as to suppose that the action of copper on the sound plants depends on the protoplasm. If there are processes going on in the sap which lead to the freeing of CO_2, the cadmium may very well act on these processes. By the duration and amount of this evolution the possibility of its being an inorganic reaction is precluded. It suggests very strikingly the accelerated respiration resulting from mechanical injuries, on which we are well informed by the work of Stich[45] and Richards.[46] But nothing hitherto known would indicate that there might be such a reaction by filtered sap. An identical performance observed by Hahn[47] in the sap of the spadix of

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[45] STICH, Die Athmung der Pflanzen bei verminderter Sauerstoffspannung und bei Verletzungen. Flora **74**: 1–57. 1891.

[46] H. M. RICHARDS, The respiration of wounded plants. Annals of Botany **10**: 531–582. 1896.

[47] M. HAHN, Chemische Vorgänge im zellfreien Gewebsaft von *Arum maculatum*. Ber. Deutsche Chem. Gesells. **33**: 3555–3560. 1900.

Arum did not suggest that the "respiration" might be abnormally vigorous, as the subject was chosen for its normally intense respiration. Hahn determined that a feature of the respiration by the Arum sap was the rapid consumption of sugar. His paper also discusses briefly the enzymes likely to be concerned. So far as can now be seen, we have here a performance which does not differ from respiration in the materials used, nor in the products, and is stimulated in the same way by mechanical violence and probably by poison, but every substance concerned in which passes through filter paper.

Enough of these tables on the action of the more fatal metallic poisons have been presented so that I anticipate that no other botanist will be attracted to the field as a promising one for conclusive work on respiration, or will imagine that a control of similar plants insures the validity of the results. The tap water experiment was a fortunate accident, where the utmost care would never have discovered the truth. It is very probable that the real respiration is accelerated by these poisons. This is indicated, for instance, in tables II and XV by the long continuance of the higher rate of respiration, and it is made more credible by the probably analogous action of K and Na still to be described.

The action of the poisons on the salts in the cell sap is not without interest in itself. The CO_2 comes ultimately from respiration; what effect freeing it may have on the respiration is problematical. In the other direction, it would seem that the reaction of the sap and the poison might protect the proteid, not of that cell, but of others. This can hardly hold good for as violent a poison as silver, but must of weaker ones, the trace of which remaining in solution would be harmless. Silver will kill Elodea in the presence of more than its equivalent of NaCl; yet I have found that tadpoles acclimated to rather strong NaCl and then thoroughly washed possess a limited immunity to silver poisoning.

There is a good general parallel between the toxicity of the various metals and their power to decompose carbonates, if that is a proper expression for the expulsion of CO_2 from the cell sap and tap water. This is conspicuously true of the three metals I have studied most thoroughly, Hg, Cu, and Zn; the more toxic the metal, the weaker the solution required to set free measureable CO_2. But this parallel is too hazardous to be dwelt upon. It appears also from the limited data at hand that the power to decompose carbonates is disposed to be parallel to the power to accelerate growth; for instance, Zn is very vigorous in proportion to its toxicity in both respects. The power to set free CO_2 is also proportional in general to the bleaching power of the different metals, as demonstrated by the solutions left with Elodea in them after the tests for toxicity.

Having found no strong metallic poison which did not drive CO_2 from the tap water, I wondered if other poisons might possess the same power. The first tried were antipyrin and iodin, both of which Jacobi found to accelerate respiration. I used such concentrations as he had done.

TABLE XXX.

May 12. Test of iodin. Experiment bottle contains Elodea in 400^{cc} "Neptune" water. Control is 400^{cc} tap water. The air after passing each runs through a small bottle containing 100^{cc} aq. dest. in which is more iodin than will dissolve.

Time	Experiment	Control
11:19–3:13	0.037	0.004
3:13 The iodin water poured into the other bottles.		
3:13–6:13	0.068	0.002
6:13–7:43	0.060	0.000

TABLE XXXI.

May 10. Test of antipyrin. Experiment and control are same as in XXX.

Time	Experiment	Control
10:59–3:49	0.030	0.002
3:49 0.25 % antipyrin in both bottles.		
3:49– 5:59	0.047	0.002
5:59– 7:59	0.050	0.007
7:59– 9:32 (13.55^h)	0.047	0.005
9:32–11:32	0.045	0.000
11:58 $\frac{N}{100}$ HCl in both bottles.		
11:58– 2:22 (total CO_2)	0.925	1.805

Both iodin and antipyrin accelerate the evolution of CO_2 from the Elodea, but not from the tap water. Their action must be on the the protoplasm. The acceleration observed was a shade greater than Jacobi's result with the same substances.

An experiment with potassium cyanid may be inserted here. The reason for performing it was the regard in which KCN is held by animal physiologists as a substance inhibiting respiration. The evidence for this rests, largely at least, on its preventing the consumption of oxygen, so that in KCN poisoning the blood retains its arterial color (its other effect in interfering with the carrying of the O by the blood being irrelevant here). I have made two tests of the evolution of CO_2 under the influence of KCN, one of which is reported here. Neither of them has the measure of quantitative exactness I could desire, but the apparent acceleration was so great it is hardly possible that it should have been an error.

TABLE XXXII.

January 22. Test of KCN. No control.

Time	Experiment
10:54–3:54	0.048
3:54	$\frac{N}{100}$ KCN in bottle.
3:56–4:56	

The alkalinity of KCN prevented the escape of more than a trace of CO_2. To determine the CO_2 then the KCN solution was made slightly acid with H_2SO_4, and the CN precipitated with $AgNO_3$. It was then boiled.

Total CO_2 - - - 0.899^{cc} N.

As a control, 400^{cc} $\frac{N}{100}$ KCN (same solution) treated in same way. The CO_2 from it was - - - - - 0.208^{cc} N,

or for 500^{cc} - - - 0.260, leaving as the CO_2 from respiration in the experiment - - - - 0.639^{cc} N.

This result, with the evidence that oxidation is hindered by KCN, suggests forcibly that it is a substance which acts on "normal" but not on "intramolecular" respiration, which would amount to a proof for the already well supported theory that the evolution of CO_2 and the taking on of O are distinct activities of the plant; the latter, when it occurs, being dependent on the former, instead of *vice versa*. The action of KCN will well repay more study, whatever it may show, but I have had no time to follow it up.

The work on chemical stimulants was concluded with tests of some of the common mineral foods. Of these, calcium nitrate caused a more active evolution of CO_2 from Elodea, but as it was found to have the same effect on tap water, its action on the plant was of questionable nature, and the table showing its effect is omitted. Sodium chlorid and nitrate, and potassium chlorid, nitrate, sulfate, and iodid were all tested as to their action on tap water, from which none of them caused any escape of CO_2. To report the individual experiments showing this would be superfluous. Excepting a number of them which illustrate an altogether novel point in connection with the death of the plants, the individual tables of the results of the application of these salts can also be dispensed with, and their places will be taken by a single table showing the per cent. of acceleration of respiration. This per cent. is computed from what seems to me to be so much of the results of the experiments as represent the action of the salts on sound, unacclimated plants.

When any of these salts were applied to the plants in concentrations of $\frac{N}{20}$ to $\frac{N}{5}$ there was a prompt increase in the rate of respiration. This quickened rate remained constant in most of the experiments for a period of from twelve hours to more than a day; then it fell steadily or rose rather abruptly. The per cent. of acceleration is figured from the steady rate following the application of the salt, as compared with the preceding hours. The length of this period of uniformly accelerated respiration depended on the condition of the Elodea, on the nature of the salt and its concentration, and on the temperature, being shorter at higher temperatures.

The desired concentration of these salts was near enough to their limit of solubility so that applying them like the strong poisons would have introduced a possible source of large error in the CO_2 dissolved or soluble in the solution applied. This was avoided by the method employed with iodin (table XXX), letting the CO_2-laden air from each Elodea culture pass through another bottle containing the salt to be applied. Thus, if I had 2N KCl, and wished to test $\frac{N}{10}$, the Elodea was placed in 400^{cc} water, and the smaller bottle contained 22^{cc} of the $\frac{N}{10}$ solution, and water to 40^{cc}. The CO_2 content of the two bottles must have been practically the same when air had been passing through them over night.

TABLE XXXIII.

Salt	$\frac{N}{20}$	$\frac{N}{10}$	$\frac{N}{5}$
NaCl	29%	..	35%
$NaNO_3$	..	34%	58 (too high; cf. XXXV)
	..	..	32
KCl	41	42	58
	29.4	48.7	52
KNO_3	39	40.4	62
	36.4	..	61
K_2SO_4	..	31	..

A single comparison of KNO_3 and KI, both $\frac{N}{10}$, showed the same acceleration for eighteen hours at about 21°C., after which the KI material took a considerable lead and was in large part dead when the experiment ended.

It appears from this summary of results on K and Na, that the former is decidedly the stronger stimulant. Jacobi (p. 302) reports a much greater acceleration by $\frac{N}{20}$ NaCl than by $\frac{N}{20}$ KCl; but in six experiments, only part of which are represented in the above table, in which KCl or KNO_3 was in one bottle and the same concentration of the corresponding Na salt in the other, I have found no single instance in which the K salt failed to produce the greater effect. Kosiński (p. 141), at the other extreme, concludes that while KNO_3 and K_2SO_4 accelerate the respiration of Aspergillus, NaCl does not do so at all. My results on the respiration harmonize perfectly with the greater toxicity of K. True[48] rates the relative toxicity of K and Na to Spirogyra at 10:6. It seems to be about the same to Elodea.

It has been found by a number of observers that chlorids and nitrates of the same metals have the same toxicity, and the relatively few contrary statements do not bear the stamp of great probability. Coupin, for instance, rates the relative effectiveness of LiCl and $LiNO_3$ as 12:5, and that of $MnCl_2$ and $Mn(NO_3)_2$ as 1 : 13. Such a result is too surprising not to be doubted until there is more evidence for it. That chlorids and nitrates of the nutrient base often act differently in experiments of long duration, when used as fertilizers, is partly due to changes in the salts themselves. But working with salts whose base acted mildly enough so that concentrations even strong enough to cause plasmolysis could be used, it would have been possible to detect differences in the toxic or stimulating power of Cl or NO_3 ions too insignificant to suggest themselves at greater dilutions. Taken altogether, the NO_3 ion has been a shade the more active in my experiments; but there is no emphatic or constant difference in the stimulating action, in the effect on the turgor, or in the toxicity.

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[48] R. H. True, The physiological action of certain plasmolysing agents. Bot. Gaz. **26**: 407–416. 1898.

Up to $\frac{M}{5}$, the stronger the salt, the greater the stimulation, but the added stimulation by no means remains proportional to the concentration; which is only another illustration of the general rule that the less of any food is present, the greater its efficiency in proportion to the amount.

I pass over any discussion of the probable mode of action of K and Na, whether as food or stimulant, because in the present state of our knowledge of the details of metabolism any such distinction in the case of essential food elements is difficult in words, and imaginary in practice.

The Elodea would always plasmolyze in 2 per cent. KNO_3 when the experiments began. In all the experiments then in which a salt was applied in the concentration of $\frac{N}{5}$ the cells must have been slightly plasmolyzed for a time. I was somewhat surprised that in such a case the extraction of water, as a purely physical process, did not operate to depress the respiration, but it seemed not to, as the acceleration was manifest from the time the salt was applied. When still stronger solutions are used, the physical action of extracting water and compressing the protoplast predominates over the chemical stimulation, and the respiration sinks below normal.

TABLE XXIV.

June 4. Test of $\frac{2N}{5}$ KNO_3 and KCl. Exp. is Elodea in 225^{cc} dist. H_2O. Small bottle has 150^{cc} $\frac{N}{1}$ KNO_3. Control Elodea in 225^{cc} dist. H_2O. Small bottle has 150^{cc} $\frac{N}{1}$ KCl.

Time	Experiment	Control
10:15– 6:09	0.073	0.070
6:09 Bottles	poured together.	
6:09– 8:27	0.063	0.059
8:27–10:39	0.064	0.057
10:39– 7:21 (8.7) hrs.	0.044	0.045
7:21– 2:09	0.052	0.077
2:09–10:09	0.140	0.144

The low figures for the third period after applying the salt are partly due to a fall of 1.3° C. in temp.

The very rapid increase in the evolution of CO_2 occurred about as long after the application of the salt as was to have been expected with a solution but half as strong, from which it appears probable that the physical action of the salt has tended to protect the plant. The case is roughly analogous to those of the seeds of Lepidium[49] and the sporocarp of Marsilea,[50] which retain their vitality indefinitely in very strong alcohol, but succumb quickly if the alcohol contains water enough to soften the coats and make them permeable.

It remains to present a few of the experiments with K and Na fully enough to illustrate, as the last table does, the final rise of the curve of respiration, usually about a day after the application of the salt.

TABLE XXXV.

May 27. Test of $\frac{N}{5}$ $NaNO_3$.

Time	Experiment
6:58–11:52	0.033
11:52 Bottles po	ured together.
11:52–6:22	0.052
10:00 P.M.–10:00 A.M.	0.038
10:00–6:00 (8 hours.)	0.087
6:00 P.M., May 28 Tested as to turgor and	found dead.
6:15–9:45	0.107

The exceptional acceleration of 58 per cent. by $NaNO_3$ (table XXXIII) comes from computing it from the first 6.5 hours of the salt's action. If 18 hours had been included it would have been only 30 per cent.

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[49] F. Nobbe, Handbuch der Samenkunde 116. Berlin. 1876.

[50] C. R. Barnes, Vitality of *Marsilea quadrifolia*. Bot. Gaz. **20**:229. 1895.

TABLE XXXVI.

May 18. Test of $\frac{N}{5}$ KCl and NaCl.

Time	Exp., KCl	Cont., NaCl
9:55–2:35	0.055	0.054
2:35	Bottles poured together.	
2:35–6:35	0.087	0.073
Record over night not kept.		
8:36 A. M.–10:36	0.099	0.064
10:36–12:36	0.097	0.071
12:36– 2:36	0.109	0.076
10 P. M.	Almost dead.	Alive.
May 20, 11:00 A. M.	Dead.	Alive; not very unsound.

TABLE XXXVII.

May 20. Test of $\frac{N}{5}$ KNO_3 and $NaNO_3$. Subject, Ceratophyllum.

Time	Exp. KNO_3	Cont., $NaNO_3$
8:35–1:41	0.021	0.0296
1:41	Bottles poured together.	
1:41–8:11	0.034	0.039
8:11–8:41 (12.5 hrs.)	0.057	0.058
8:41–11:41 (May 21)	0.073	0.053
11:41–11:53 (12.2 hrs.)	0.044	0.043

This experiment carried the plants past the point of most excessive combustion. The temperature during it was about 24.6°C.—the highest in any of these experiments.

TABLE XXXVIII.

June 2. Test of $\frac{N}{5}$ KNO_3 and KCl.

Time	Exp., KNO_3	Cont., KCl
8:37–12:43	0.028	0.027
12:43	Bottles poured together.	
12:43–10:43	0.045	0.041
10:43–10:46 A. M.	0.067	0.074
10:46–9:46 (June 3)	0.068	0.078

The plants were "dead" at 10:46 A. M., June 3.

As already mentioned, plants treated with $\frac{N}{10}$ KI showed this phenomenon, but the parallel culture with KNO_3 did not while the experiment lasted.

This excessive evolution of CO_2 is undoubtedly a feature of the death of the plant. It is not easy to fix a time at which it begins, because the cells in a single leaf do not all die together; but it is conspicuous while a very large part of the material is still evidently alive. It continues after the entire material, judged by its appearance under the microscope or by the test of plasmolysis, would be called dead. Two conceivable sources of this CO_2 suggest themselves; it might be allowed to escape by the removal of an obstruction when the protoplasm dies, as the acid in sour leaves gets an opportunity to destroy the chlorophyll; or else its origin is in the protoplasm itself. As we have every reason to suppose, and none to doubt, that CO_2 diffuses readily through the living protoplasm, the first of these suggestions may be dismissed, and we may accept it as a fact that the escape of a large amount of CO_2 is not merely an accompaniment of death, but is a part of death.

If the phenomenon is thus fundamental in the demise of the plant, it must occur under other fatal conditions beside poisoning. In the experiments in which plants were boiled there was an amount of CO_2 evolved for which I was at the time quite unable to account. And I have had several opportunities to observe an increase of apparent respiration as Elodea succumbed to prolonged exposure to too high a temperature. Two of these follow; the first is an extract from the same experiment as table XI, showing the behavior of the control later in the day; during the hours included in table XI the control had been reasonably steady.

TABLE XXXIX.

December 10. Elodea at 39-41° C.

Time	Control
6:30- 8:05	0.087cc N. per hr
8:05- 9:05	0.105
9:05-10:05	0.100
10:05-11:05	0.150
11:05-12:05	0.135
12:05-11:05 (11 hrs.)	0.143
11:05- 1:05	0.117

In the experiment recorded in table XL the rise in the control occurred in time to invalidate the results of the experiment culture.

While I have observed this feature of death only as a result of poisoning and of heat, it appears to me very possible that the immediate evolution of CO_2 when tubers were cut in Richards's work (*l. c.* 1896, p. 544) should be explained in the same way. CO_2 diffuses through cork so much more readily than does O that a great accumulation of it within the tuber, to be set free from any exposed surface, seems hardly natural. Kolkwitz[51] finds that grain ground to meal, soaked in alcohol, or heated to 100° C., all processes calculated to kill it, still gives off a very appreciable amount of CO_2. The behavior of Elodea sap might point in the same direction, though the consumption of large quantities of sugar, observed by Hahn in in the sap of Arum, demands a different interpretation.

TABLE XL.

December 6. Elodea at 39–41 C.

Time	Control
4:30– 5:30	0.070
5:30– 7:30	0.085
7:30– 9:30	0.097
9:30–11:30	0.110
11:30– 1:30	0.110

The evolution of CO_2, not only as a phase of death, but as a process continuing indefinitely after death, is another question on which I have sought for light. Reinke[52] has said that in the presence of atmospheric O dead seedlings and leaves continue to evolve CO_2 at ordinary temperatures, and his statement that no microorganisms are responsible for the phenomenon ought to be reliable. Schlösing[53] and Berthelot and André[54] have found CO_2 given off at high temperatures, 70–110° C., under the most various conditions. If these observations admitted of general repetition, all of our determinations of dry weights would be proven not to represent the entire solid matter of the plant.

My experiments with Hg, Cu, and Zn, which seemed at first to be the most striking proof of indefinite loss of CO_2 after death, can no longer be regarded as any positive evidence on the subject. The evolution from plants killed by K and Na decreased after they had been dead a few hours. The solubility of CO_2 in water makes my usual method of experimenting inappropriate to the determination of a time when CO_2 may cease to be evolved. I have tried one experiment which proved that if Elodea is left in water and kept at about 90° C. the evolution of CO_2 gradually diminishes, but at the end of four days is still as rapid as in the ordinary respiration of the same plants. As a control the same amount of material was placed in so little water that it became dry within twenty-four hours, and the evolution of CO_2 fell to a trace, without, however, quite ceasing. The material was again wetted and considerable CO_2 was evolved, though less than from the material which had been kept in water. It would appear from this that the usual dry-weight determinations are practically valid, and a number of tests which I have made with seeds show that at most a trace of CO_2 escapes as they dry at 100° C., or even a few degrees higher.

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[51] R. KOLKWITZ, Ueber die Athmung ruhender Samen. Ber. Deutsch. Bot. Gesells. **19**: 285–287. 1901.

[52] J. REINKE, Zur Kenntniss der Oxydationsvorgänge in der Pflanze. Ber. Deutsch. Bot. Gesells. **5**: 216–220. 1887.

[53] T. SCHLÖSING, Sur la combustion lente de certaines matières organiques. Comptes Rendus Acad. Sci. Paris **108**: 527. 1889.

[54] BERTHELOT ET G. ANDRÉ, Études zur la formation de l'acide carbonique et l'absorption de l'oxygéne par les feuilles détachées des plantes. Comptes Rendus Acad. Sci. Paris **118**: 45–54. 1894.

SUMMARY.

The method has been perfected until the results are reliable to one-fiftieth of a milligram.

No poison has been found *not* to act as a stimulant.

Metallic salts drive CO_2 from carbonates in the cell sap. This pseudo-respiration, under the action of strong poisons, is many times as active as the real respiration, and makes the study of the latter impossible.

CO_2 is given off from filtered sap squeezed from Elodea much more rapidly than from the Elodea before injury.

The stimulation by K salts is greater than that by Na salts, in about the proportion of their relative toxicity. No constant difference was found between chlorids and nitrates.

A considerable evolution of CO_2 is a feature of the breaking down of "protoplasm" into mere "proteid," in death.

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THE EMBRYOGENY OF ZAMIA.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XLV.

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(WITH PLATES VI–VIII)

OUR knowledge of the development of the embryo of Cycadales is very meager, being largely included in Treub's (5) account of *Cycas circinalis* and Ikeno's (8) of *Cycas revoluta*. These two accounts agree in every important particular, and deal chiefly with the development of the proembryo. The following facts were established: the egg nucleus divides, and successive simultaneous divisions give rise to a large number of free nuclei; the cytoplasm of the central region of the egg becomes vacuolate and then completely disorganizes; the remaining cytoplasm becomes parietal, massing somewhat toward the bottom of the egg; in this parietal layer the numerous free nuclei are imbedded, being equidistant from one another and forming usually a single layer except at the base of the egg, where simultaneous nuclear division begins again; later, walls appear, and the proembryo becomes a sac somewhat thickened at base, but with the wall composed of one or at most two layers of cells. This history differed so much from that of Ginkgoales and of Coniferales as known at that time that it seemed to stand somewhat stiffly apart among gymnosperms.

A series of collections of *Zamia floridana* was obtained from southern Florida during the spring and summer of 1902. Some collections consisted only of the ovulate strobili, but in most cases the entire plant was secured. As stated by Webber (11), the ovulate strobili continue in their development for some time after removal from the plant, and we have observed mitotic figures in ovules after the strobilus had been lying in the laboratory for nearly two weeks. Entire plants sent from Florida in June and July were potted, and they continued to develop quite normally, a large proportion of the ovules becoming seeds with fully formed embryos. The material yielded a fairly complete series of stages from a period somewhat before fertilization to the ripening of the seeds.

The presence of a ventral canal cell among the Cycadales was for some time in question. Strasburger (**2**) seems to have been the first to recognize it in 1876 in *Cycas sphaerica*, and in 1877 Warming (**3**) reported a ventral canal cell in *Ceratozamia robusta*, but soon (**4**) decided that he had been mistaken. In 1884 Treub (**5**) failed to find one in *Cycas circinalis*, and the impression became general that no such cell is formed among Cycadales. In 1896, however, Ikeno (**6**) announced that a ventral canal cell is formed in *Cycas revoluta*, and in a later paper (**8**) he figured and described the mitosis that separates the nuclei of the ventral canal cell and egg. In 1897 Webber (**7**) reported that in Zamia "a small cell is cut off at the apex of the archegonium, which corresponds to the canal cell of Conifers."

In our study of Zamia the mitotic figure was found which gives rise to the nuclei of the egg and ventral canal cell (*fig. 1*). The chromosomes are very slender and inconspicuous, and the spindle is somewhat multipolar. Considering the great size of the central cell, the whole structure is extremely small and might easily escape notice unless well stained. After the mitosis is completed the nucleus of the egg begins to enlarge and to move toward the center of the cell, while the other nucleus becomes smaller and soon disorganizes (*fig. 2*). It will be seen from *fig. 2* that there is no wall between the two nuclei, and we were not able to find any case in which a definite ventral canal cell had been cut off.

The protuberance in which the ventral canal nucleus lies rapidly disorganizes and remains for a time as a more deeply staining mass at the top of the egg. It seems probable that in his first account Warming (**3**) was describing as a ventral canal cell the disorganizing protuberance in which the ventral canal nucleus lies. Ikeno's *fig. 11* (**8**) seems to be almost identical with our *fig. 2*, and although he states that "this portion (the protuberance) becomes completely separated from the egg cell," it is difficult to see how a wall such as usually separates the ventral canal cell from the egg could be formed after the achromatic figure has disappeared. It seems more likely that here, as in Zamia, the disorganizing protuberance might have been taken for a cell, and Ikeno himself in a brief note at the close of his paper on Ginkgo (**10**) admits that the wall may be lacking. In Ginkgo, which in so many features resembles the Cycadales, a definite ventral canal cell is separated from the egg by a wall, as figured by Strasburger (**1**), and the details of the mitosis are described by Ikeno (**10**), who figures a conspicuous cell plate at the telophase of division.

The Coniferales present some variation in the formation of the ventral canal cell; in most of the cases reported a definite wall being formed between the two nuclei, but in Cephalotaxus (Arnoldi, **9**), in Taxodium and Podocarpus (Coker, **12**), and in Thuja (Land, **13**), no wall is formed. Arnoldi's statement that the ventral canal cell is lacking in the Cupresseae certainly does not hold for the group, and it is doubtful whether such a cell or at least a nucleus representing it is absent in any gymnosperm. It would be of interest to know whether in any of the Cycadales a definite wall is formed between the nuclei of the egg and ventral canal cell. Since such a wall is uniformly present in the bryophytes and pteridophytes, its absence among the Cycadales would have to be regarded as a case of suppression.

Our preparations of the fertilization stages in Zamia merely confirm the very full account recently published by Webber (**11**).

The immense size of the fertilized egg of Zamia is a matter of surprise to any who are not familiar with the archegonia of Cycadales. The fertilized egg is usually 3^{mm} in length, and its nucleus is plainly visible to the naked eye, often reaching a length of 1000μ, as shown in *fig. 3*, which shows the actual size of the upper portion of the gametophyte with two archegonia.

After fertilization there is a period of free nuclear division. These divisions are simultaneous (*fig. 4*) and follow one another with such rapidity that the nuclei become smaller at each successive division. The first nuclear division was not found in our preparations. Webber (**11**) observed the second division and states that the first two divisions occur near the center of the egg, and that the nuclei then become scattered, and that "finally in the first stage of the organization of the embryo form a layer of cells about the periphery of the egg cell." We were able to count the nuclei in the 16-nucleate and 32-nucleate stages, being of course the product of the fourth and fifth simultaneous divisions. The 64-nucleate and 128-nucleate stages were counted approximately. In two cases the mitotic figures of the eighth division, which gives rise to the 256-nucleate stage, were counted with considerable certainty, assuming, as seems safe, that these early divisions are all simultaneous. In both of these series, which consisted of more than fifty sections, from several of which the proembryo had been lost in making the preparations, over one hundred figures were counted. Since the seventh division would show only 64 figures and the ninth division 256, there could hardly be a possibility of mistaking this stage. A section from one of these series is represented in *fig. 4*.

The entire mitotic figure is formed within the nuclear membrane, which does not disappear until the anaphases are reached. The kinoplasmic portions of the figure are highly developed, the polar radiations being particularly conspicuous. The whole figure differs decidedly from the one concerned in the formation of the ventral canal nucleus (*fig. 1*), for in this case the nuclear membrane disappears before the metaphase is reached, and there are no polar radiations whatever; and also from the later divisions in the embryo, in which the nuclear membrane disappears early. That simultaneous divisions cease with the eighth division may be regarded as certain, for numerous preparations of the proembryo just before the formation of the cell wall (*figs. 5, 6*) fail to show even approximately the large number of nuclei (512) which should be found if a ninth division had taken place.

The appearance of the proembryo at the close of free nuclear division, but before the formation of any cell walls, is shown in *figs. 5* and *6*. In both these figures the nuclei are scattered throughout the entire egg, there being no tendency to form a large central vacuole with consequent parietal placing of the nuclei, as in Cycas. In the stage represented in *fig. 5* the nuclei are more numerous in the lower part of the proembryo, doubtless on account of the settling of some of them. This settling is sometimes very evident, the nuclei being lined up along strands of cytoplasm, which appear almost as definite as bundles of spindle fibers, although they are only such trails as might be caused by nuclei passing rapidly through the cytoplasm. Very similar appearances were noticed in eggs which had been ruptured by the pressure of the razor in cases where the portion containing the archegonia had been cut out previous to placing in the fixing fluid. In these cases the trails were caused by the rapid movement of the cytoplasm toward the point of exit.

It is worthy of note that in most of our preparations of the early stages, including the eighth simultaneous nuclear division (*fig. 4*), the nuclei are nearly all in the lower half of the egg; while in later stages (*figs. 5–10*) the upper portion is never free from nuclei. In this connection it should be noted also that just before the appearance of cell walls (*figs. 5–6*) the number of nuclei is often more than 256, although never so many as 512, the number which would result from a ninth simultaneous division. It seems probable that many of the nuclei in the upper part of the proembryo, which is not to form any part of the embryo proper, are due to irregular or amitotic division. It is certain that the nuclei of this region are irregular in size and often amoeboid in outline. Some of these nuclei may have been due to the entrance of two male cells, one remaining near the apex and dividing. The two large irregular nuclei shown in *fig. 4* suggest this explanation. While the ventral canal nucleus might divide and give rise to nuclei in this region, we have seen nothing which would make such an explanation probable.

Ikeno's (8) account indicates that even in the earlier stages of development the embryo of Cycas differs considerably from that of Zamia. In Cycas, as in Zamia, fertilization is followed by a period of free nuclear division, but in *Cycas circinalis* (Treub, 5) and also in *C. revoluta* (Ikeno, 8) a large central vacuole is soon formed. According to Ikeno, who gives a more detailed account, the nuclear division near the neck of the archegonium may be amitotic; after the number of free nuclei has become quite large, the vacuole is formed by the disorganization of the cytoplasm and free nuclei of the central portion of the egg. After the vacuole has become established there remains at the base of the egg a rather dense mass of cytoplasm containing numerous free nuclei, while the cytoplasm in other parts of the egg is reduced to a thin peripheral layer with comparatively few nuclei. At this period free simultaneous nuclear division is resumed in the region at the base of the egg, which is apparently quite sharply marked off (Ikeno, **8**, *fig. 49*), so that there are two rather definite periods of free nuclear division. In Zamia (*figs. 3, 5, 10*) there is only one period of free nuclear division, and no vacuole is formed during these early stages or even after the suspensor has begun to elongate, the free nuclei of the upper portion being scattered throughout the cytoplasm. Even in stages more advanced than that shown in *fig. 10* a vacuole has not yet formed, although the cytoplasm is becoming very scanty in the region which in Cycas is occupied by the large vacuole. Of course in later stages of development (*fig. 11*) the entire region, which in *fig. 10* is occupied by cytoplasm and free nuclei, becomes empty.

In the formation of cell walls also Zamia differs from Cycas. In *Cycas circinalis* walls are formed throughout the entire region occupied by nuclei, while in Zamia the formation of walls is restricted to rather a limited area at the base of the egg. The earlier walls (*fig. 7*) are formed as in the endosperm of those angiosperms in which a period of free nuclear division precedes the formation of cell walls, excepting that in Zamia we have never found more than one nucleus in a cell, as sometimes occurs in angiosperms. At first the cells are all of the same size, but very soon those at the base begin to stain more deeply, and on account of more rapid division become smaller than those above them (*fig. 8*). The differentiation soon becomes quite marked, and the elongating cells of the suspensor can be distinguished easily from those of the embryo proper (*fig. 9*). In the last-cited figure, as well as in *figs. 8* and *10*, it may be seen that just above the definitely walled cells there is a region where wall formation is indefinite and incomplete, and that beyond this no walls are formed.

The rapid elongation of the suspensor (*figs. 13–16*) forces the embryo down into the endosperm. The resistance is so great that in later stages the base of the embryo is forced upward into the archegonial chamber and is stopped only by the hard seed coat. The suspensor is long and twisted. When straightened out (*fig. 11*) it may be fully 5^{cm} long.

Certain features of the mature embryo may mentioned. The two cotyledons are free at apex and base, but are more or less completely fused in the middle region. The long cotyledons (*fig. 12*) constitute much the larger part of the embryo, the whole axis being comparatively small. The plumule is well developed, several leaf primordia being evident. Several branching mucilage canals extend from the root to the tips of the cotyledons. According to Warming (4) the embryo of Ceratozamia has only one cotyledon, a part of the meristematic apex of the axis becoming differentiated into the single cotyledon and the rest forming the stem tip.

These results with Zamia have enabled us to arrange a suggestive series of gymnosperms as shown by the accompanying diagram (*fig. 17*). In the first series a gradual reduction in the number of free nuclei is shown. In Ginkgo, Cycas (?), and Zamia it would seem that eight successive simultaneous nuclear divisions precede wall formation, resulting in 256 free nuclei. Among the Coniferales there is a sudden drop in the number of free nuclei, but at the same time a diminishing number from 32 to 4, as follows: Taxus 32; Cephalotaxus, Podocarpus, and Taxodium 16; Thuja 8; Pinus 4. While these numbers probably represent the usual condition, the higher numbers are not entirely constant, wall-formation sometimes occurring at an earlier division than usual. For example, in Podocarpus wall-formation may occur after the third division, but usually only after the fourth; while in Taxus wall-formation has never been observed to occur until after the fourth division, and often only after the fifth. Further reduction in the number of free nuclei occurs among the Gnetales, Ephedra sometimes showing only a

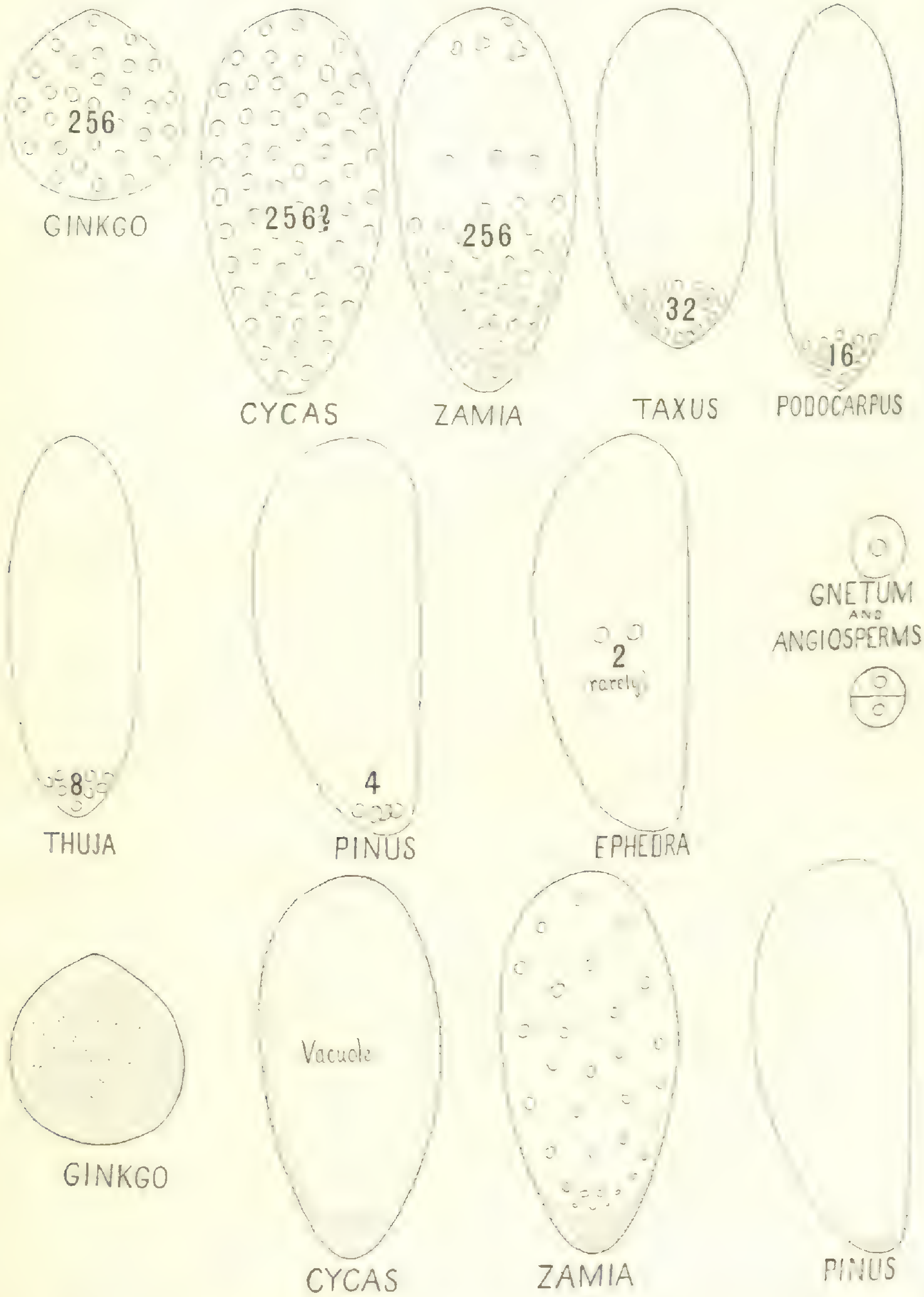
256
GINKGO
256?
CYCAS
256
ZAMIA
32
TAXUS
16
PODOCARPUS
8
THUJA
4
PINUS
2
(rarely)
EPHEDRA
GNETUM
AND
ANGIOSPERMS
GINKGO
Vacuole
CYCAS
ZAMIA
PINUS

FIG. 17. A series of diagrams to illustrate the extent of free nuclear division and wall-formation; the shaded portions of the last four figures represent the region of wall-formation.

single free nuclear division, resulting in two free nuclei; and in Gnetum and Tumboa no free nuclear division occurs at all. These last-named forms have reached the condition of the embryogeny of angiosperms, in which the first division of the nucleus of the egg is accompanied by the formation of a wall. The gap between Zamia with its 256 free nuclei and Taxus with its 32 may seem great at first sight; but it should be noted that it represents the omission of only two successive divisions, the sixth and seventh. It is entirely possible, therefore, that these missing numbers (64 and 128) may be found among the numerous Cycadales and Coniferales that await investigation.

In the second series shown in the diagram a later stage is presented. In this series Ginkgo is clearly at one extremity with its numerous free nuclei equally distributed, and its wall formation resulting in a proembryo that completely fills the egg. In Cycas the free nuclei do not remain evenly distributed, but there is a massing toward the base of the egg, and most of the remaining nuclei through the formation of a central vacuole pass to the periphery and enter into the formation of a parietal layer. In Zamia wall-formation is still further restricted, appearing only in connection with the basal nuclei. There is also no development of a central vacuole, and hence no parietal placing of free nuclei. In Zamia, therefore, a tissue that fills the sac, as in Ginkgo, or that lines the egg, as in Cycas, is reduced, and its formation is restricted to the basal region, as in Coniferales. In passing from this condition, represented by Zamia, to the condition displayed by the Coniferales, there is a gradual reduction in the number of nuclei that enter into the formation of this basal tissue, and as a result a gradually more definite setting apart of the function of each particular nucleus. For example, in Zamia the suspensor cells are not recognizable until they begin to elongate; in Taxus with its 32 nuclei, and in Cephalotaxus, Podocarpus, and Taxodiun with their 16, there is no setting apart of a distinct suspensor-forming layer; while in Thuja with its 8 nuclei a distinct suspensor-forming layer is recognized, and this definiteness is continued into the 4-nucleate forms.

It would seem to follow from these considerations that the embryogeny of Ginkgo is the most primitive one among gymnosperms; that the embryogeny of Cycas is more primitive than that of Zamia; that in its embryogeny Zamia approaches more nearly the Coniferales than does Cycas; that such forms as Taxus, Cephalotaxus, Podocarpus, Taxodium, and Thuja show progressive stages of embryogeny from that of Zamia toward that of Pinus; that Ephedra has the most primitive embryogeny among the Gnetales; and that Gnetum and Tumboa resemble the angiosperms in the elimination of free nuclear division from their embryogeny.

UNIVERSITY OF CHICAGO.

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EXPLANATION OF PLATES VI–VIII.

All the figures are from *Zamia floridana*. *Figs. 13–16* are from photomicrographs of rather thick sections. The rest of the figures, except *figs. 3, 11, 12*, are from camera lucida drawings.

FIG. 1. The mitotic figure which gives rise to the nuclei of the egg and the ventral canal cell. × 200.

FIG. 2. A later stage showing the two neck cells (*a*), the ventral canal nucleus (*v*), and the nucleus of the egg (*e*). × 45.

FIG. 3. Upper portion of the gametophyte showing two archegonia; the nucleus of the fertilized egg (*n*) is plainly visible to the naked eye. *Natural size.*

FIG. 4. Free simultaneous nuclear division in the proembryo; the number of mitotic figures in this proembryo is estimated at 128; the two large irregular nuclei at the top may have come from a male cell; the spindle-shaped bodies at the top are probably coagulated food material. × 25.

FIG. 5. Proembryo after simultaneous free nuclear division has ceased; the remains of the blepharoplast (*b*) can still be seen. × 20.

FIG. 6. A stage slightly later than that shown in *fig. 5*; the strands at the bottom seem to be related to the settling of the nuclei. ×20.

FIG. 7. The beginning of wall-formation at the base of the proembryo. × 20.

FIG. 8. Differentiation into suspensor and embryo proper becoming distinguishable. × 30.

FIG. 9. A more advanced stage, the embryo and suspensor being quite definitely outlined; the faint and incomplete septation above the suspensor is also shown. ×50.

FIG. 10. A still later stage; the suspensor has lengthened considerably; no central vacuole has yet been formed, although the cytoplasm in the region occupied by the vacuole in Cycas at this stage and earlier is becoming scanty. × 36.

FIG. 11. Young embryo dissected out from the seed; the suspensor has been pulled out straight. *Natural size.*

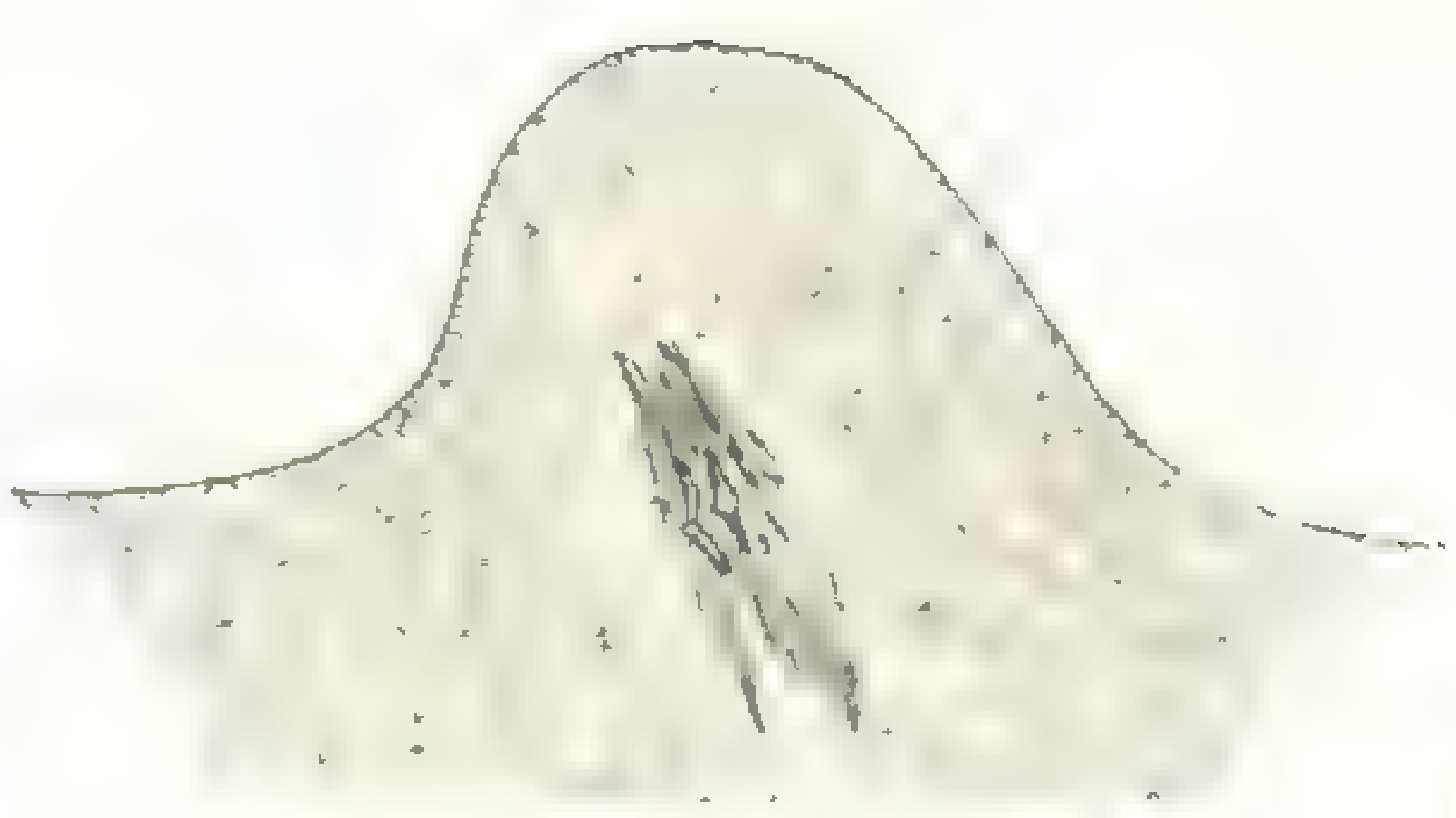
FIG. 12. A nearly mature embryo, showing the two cotyledons and suspensor. *Natural size.*

FIG. 13. Upper part of gametophyte showing embryo and characteristic cavity formed by disintegration of surrounding tissues. × 14.

Fig. 14. Three embryos in about the same stage as that shown in the preceding figure. ×45.

FIG. 15. Tip of young embryo pressing into the endosperm. × 185.

FIG. 16. Young embryo with a portion of the suspensor. × 140.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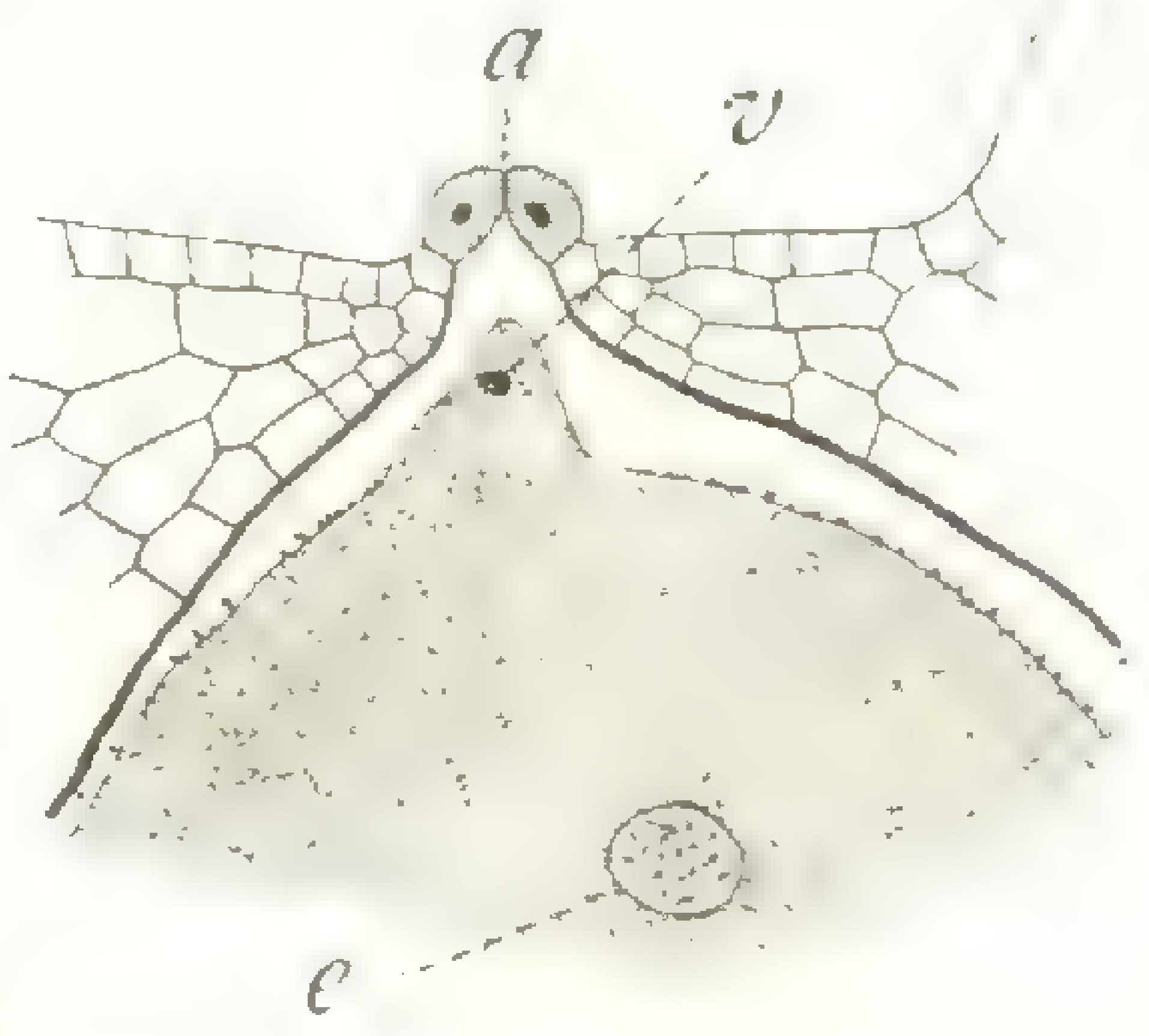

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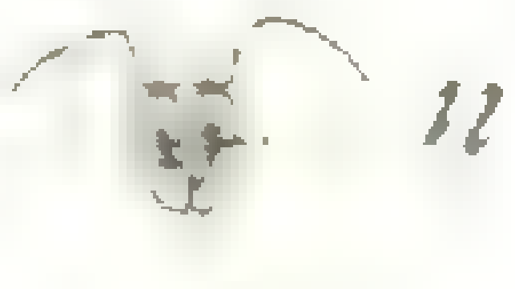

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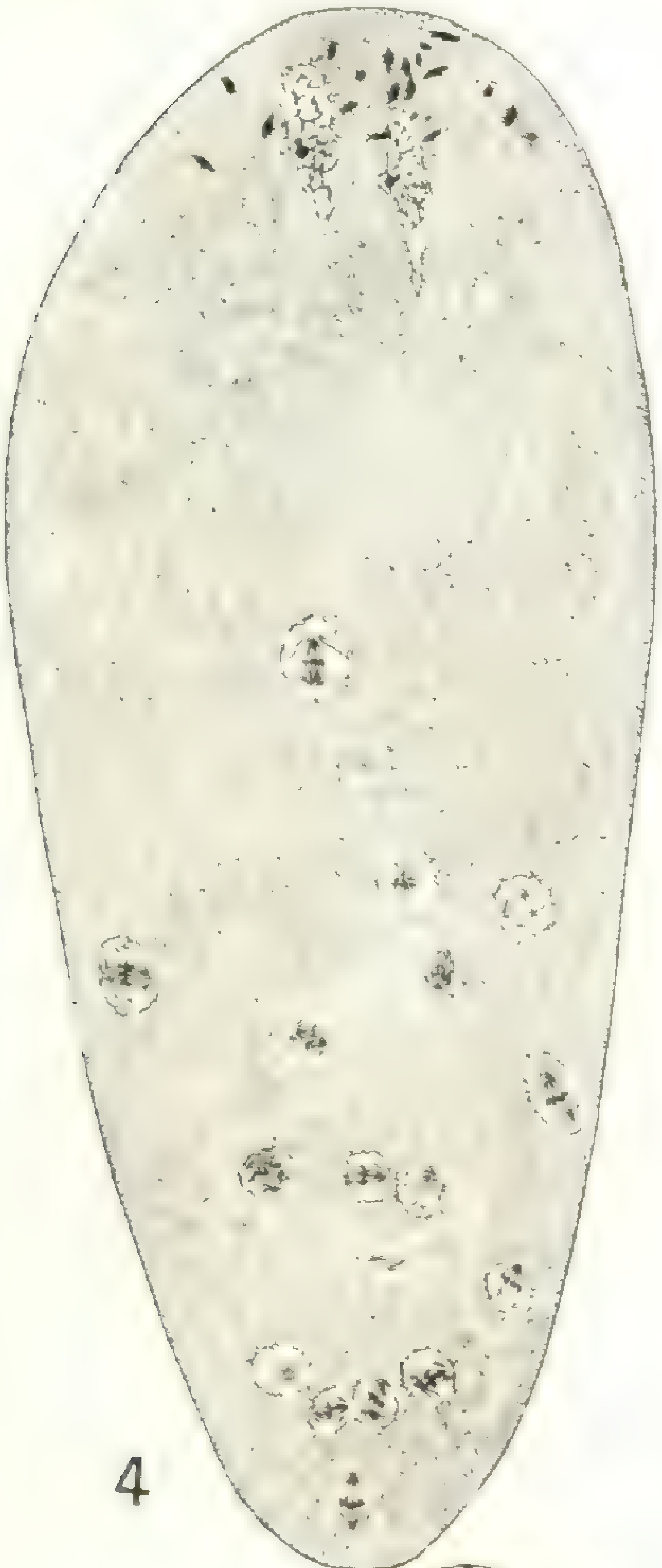
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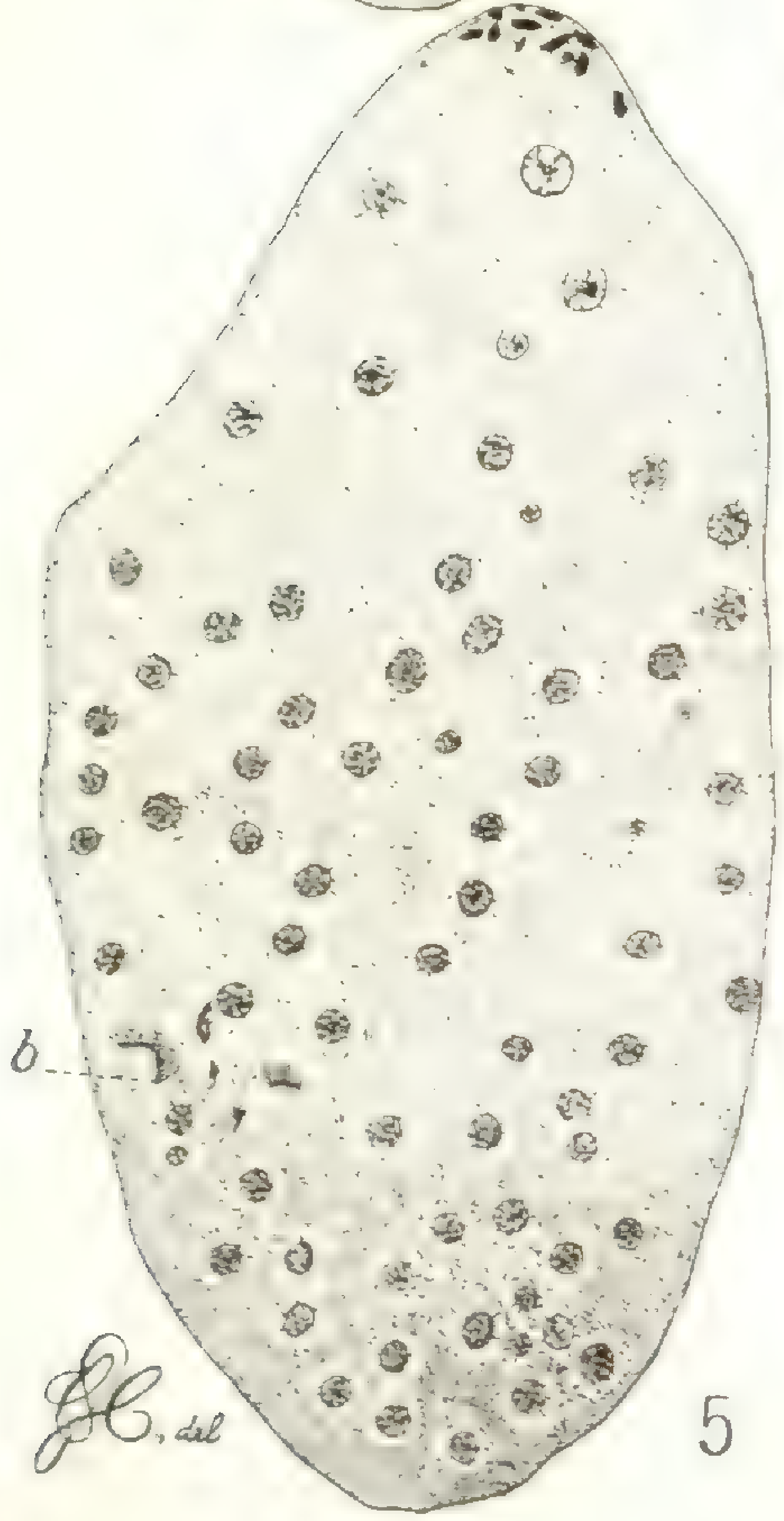

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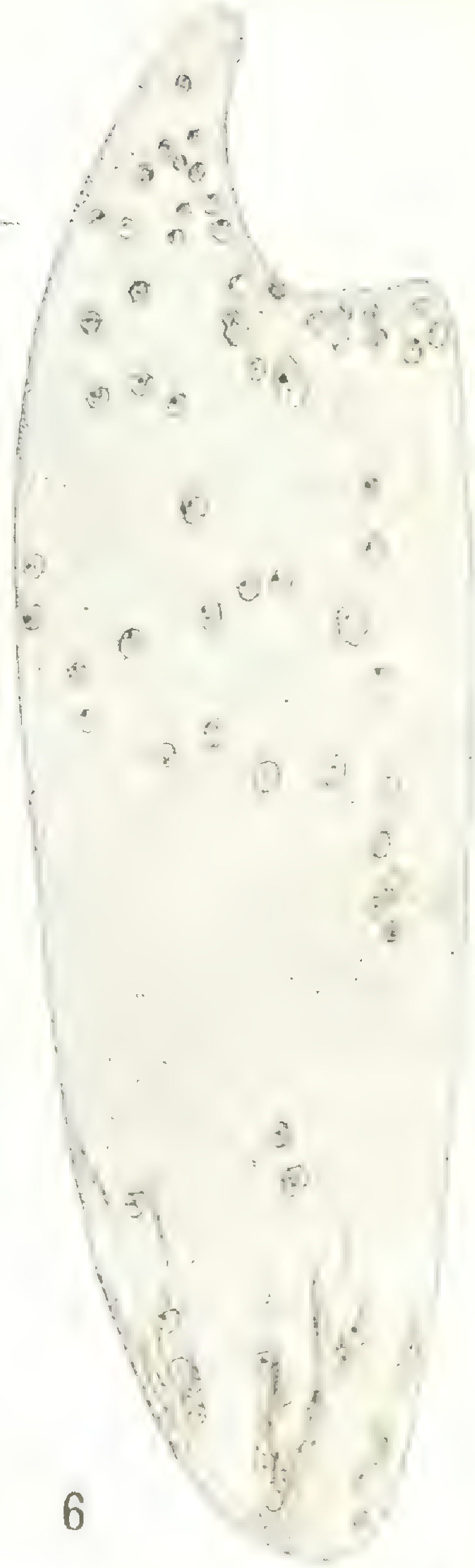
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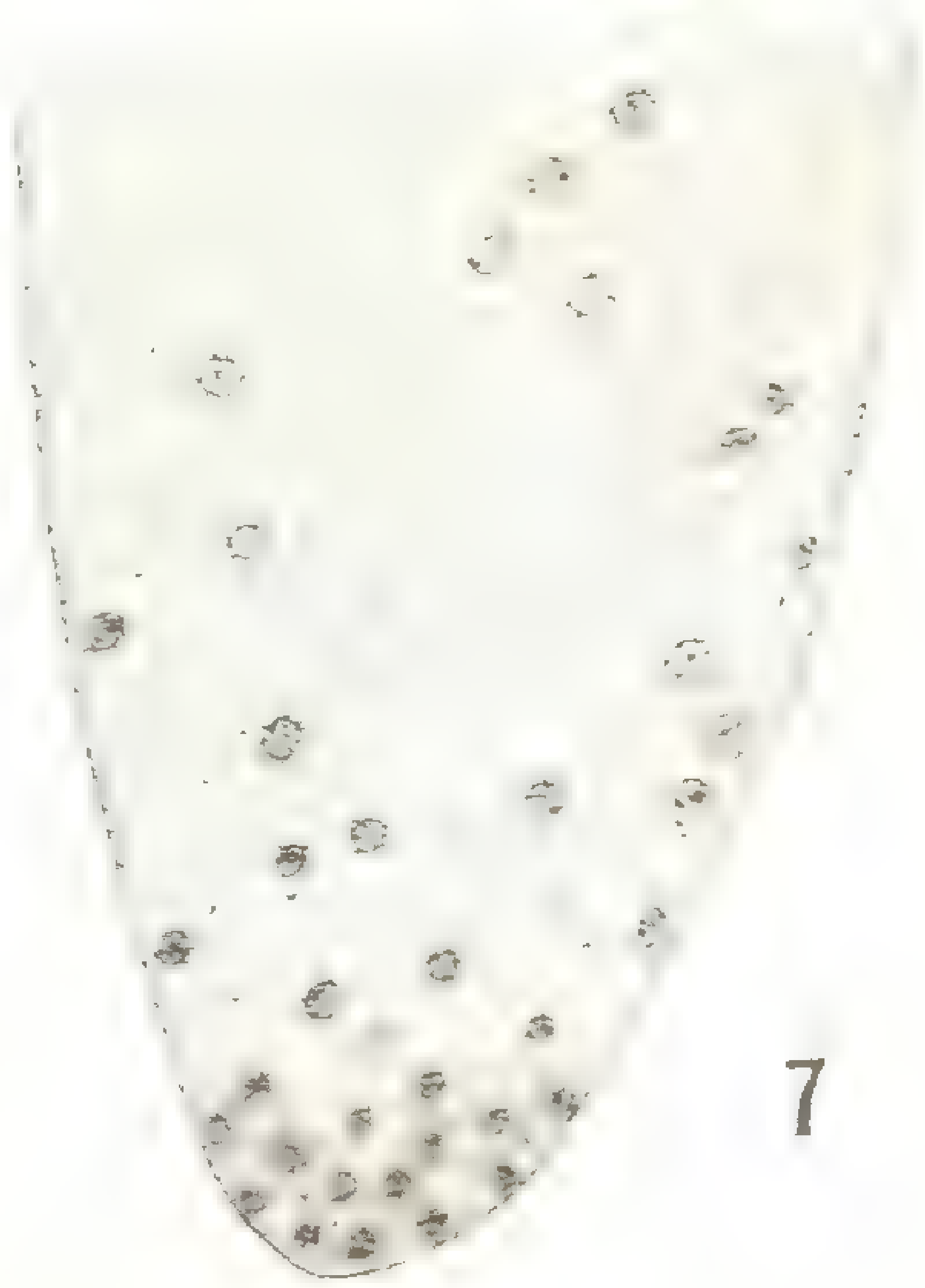
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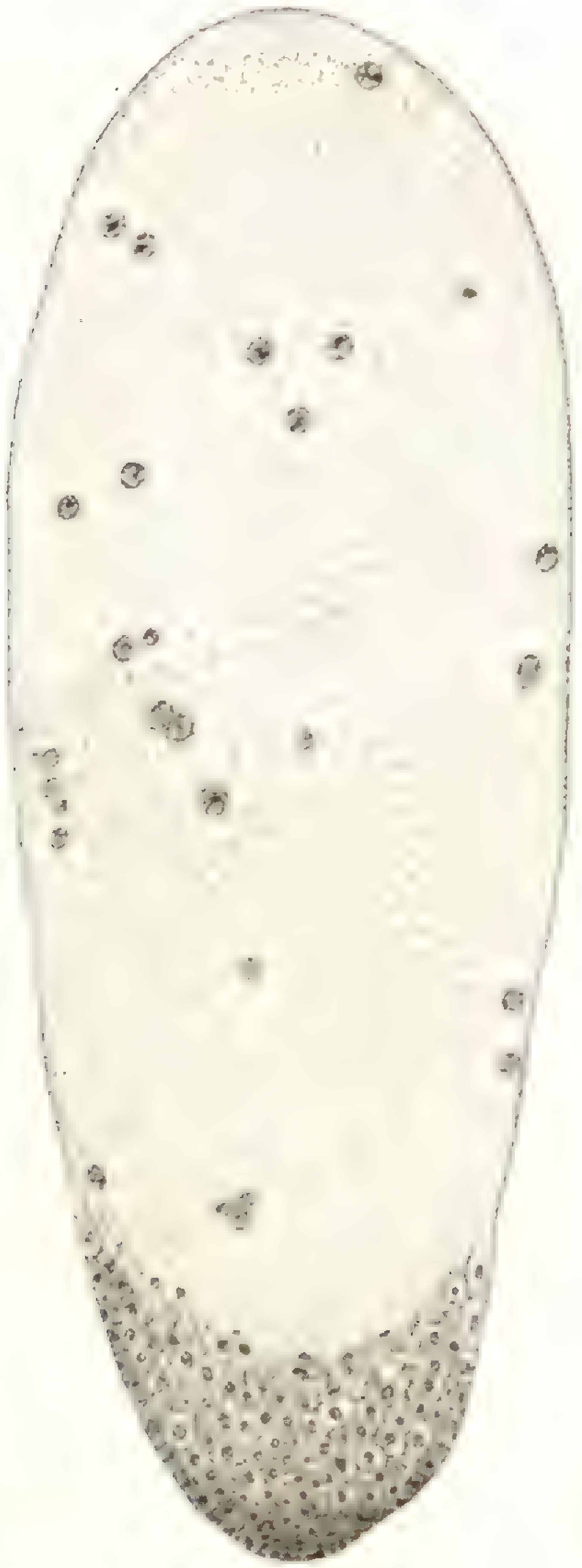
COULTER and CHAMBERLAIN on ZAMIA



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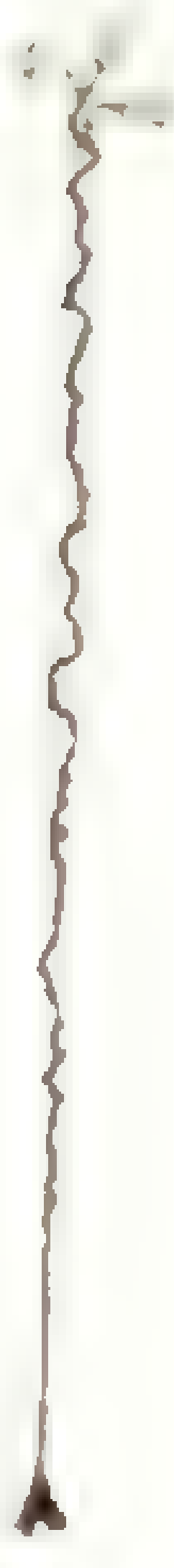

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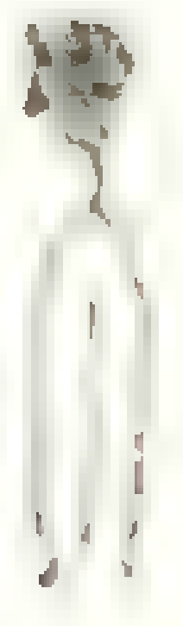

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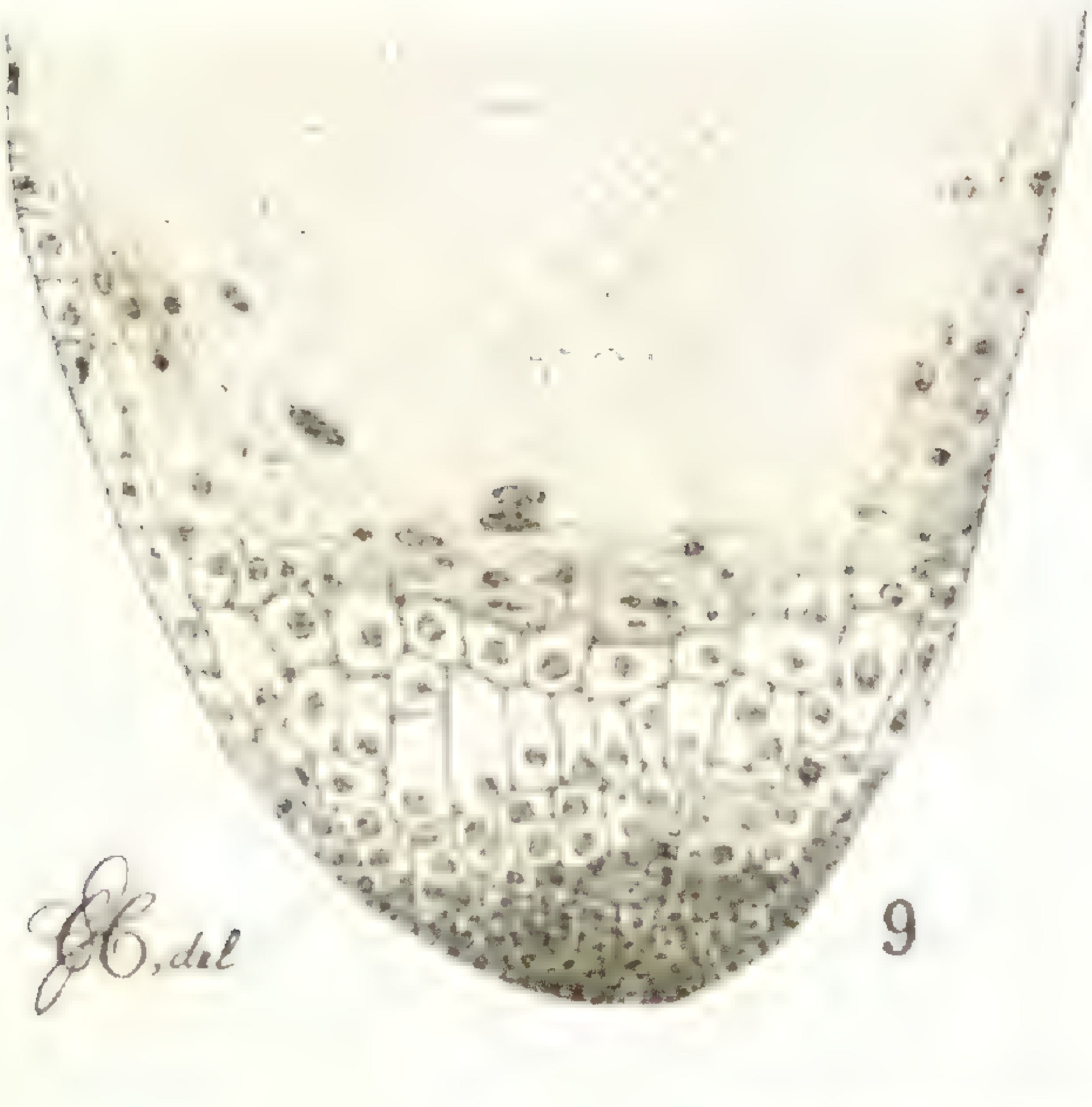

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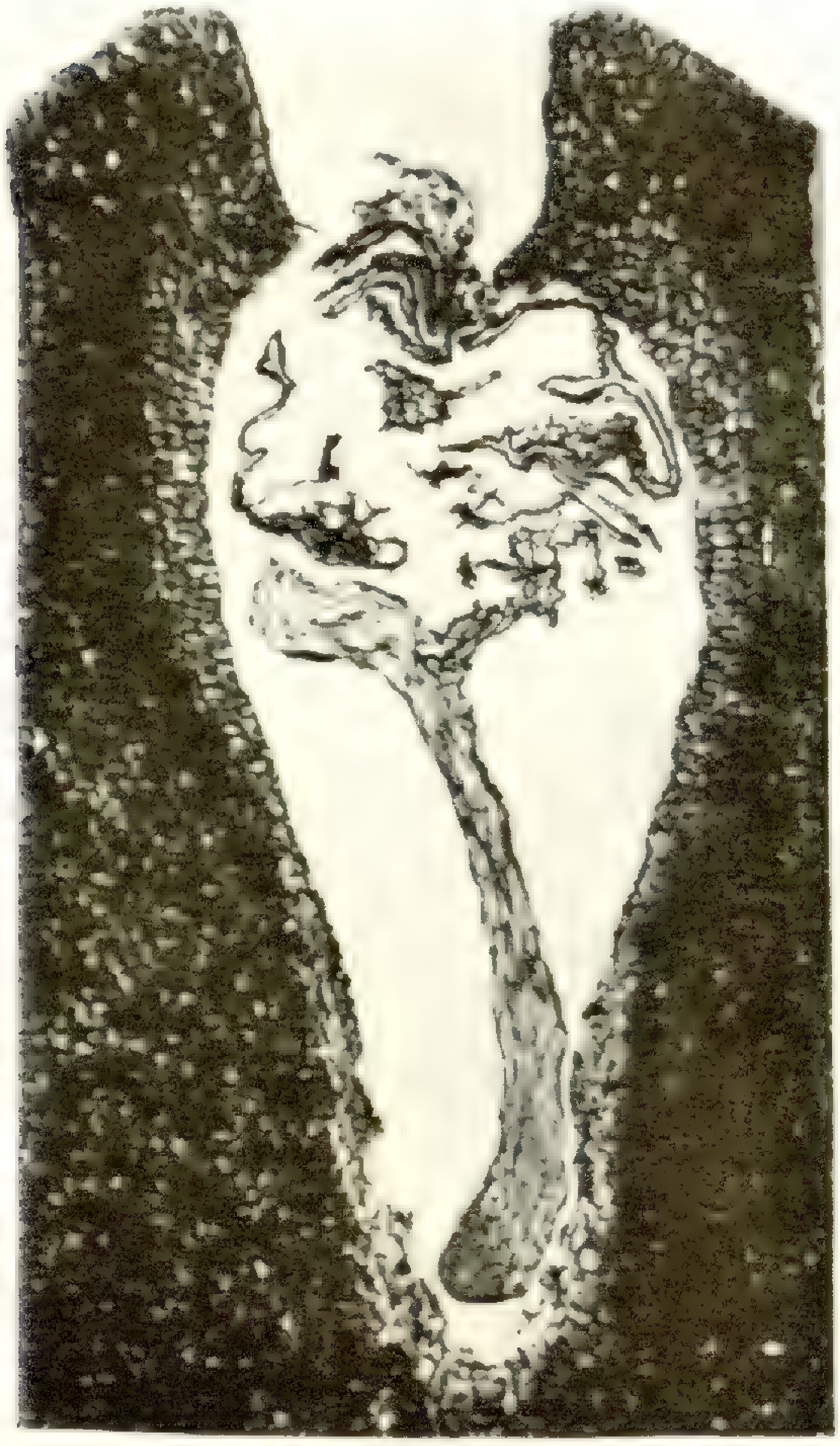
COULTER and CHAMBERLAIN on ZAMIA



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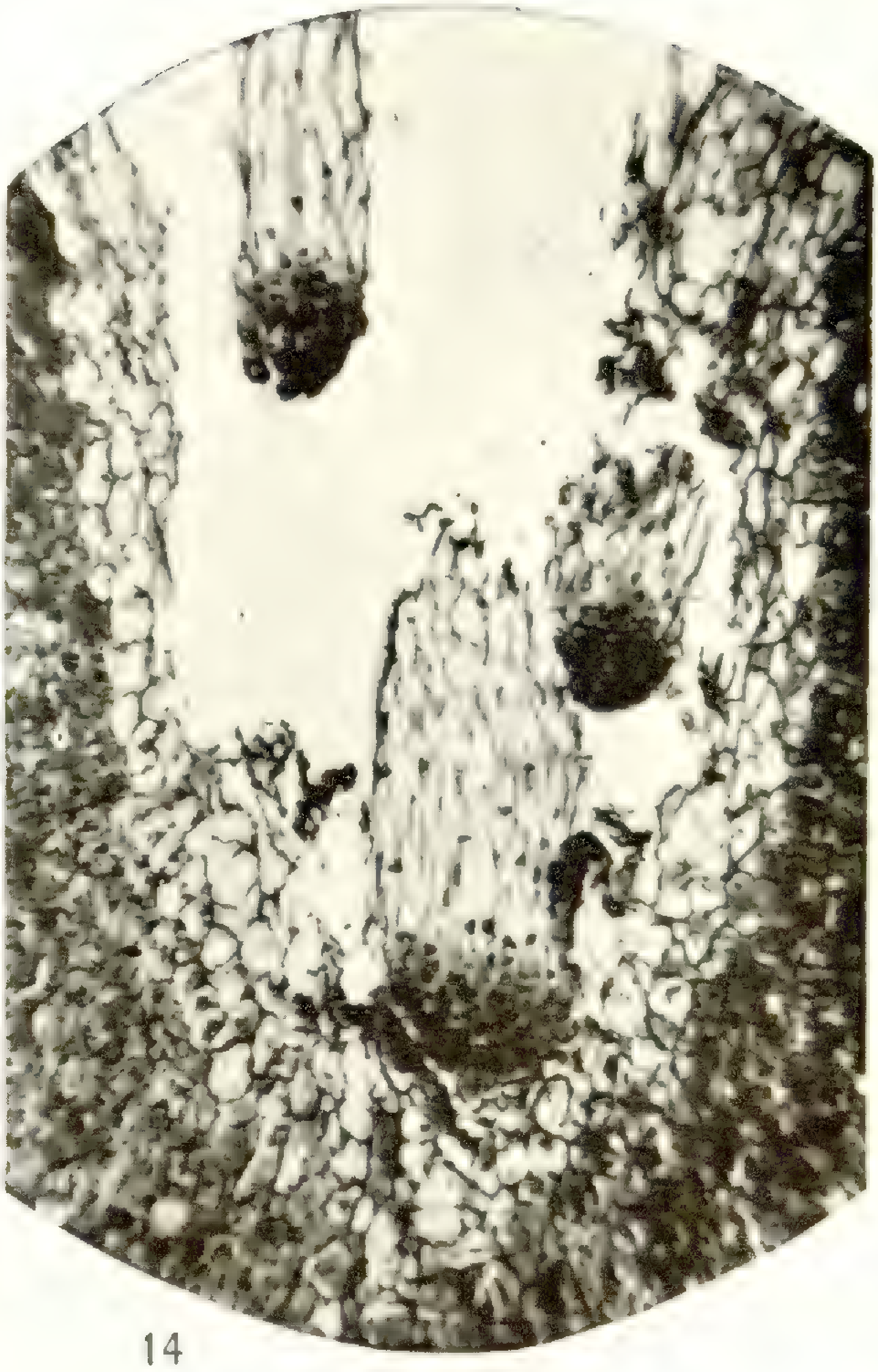

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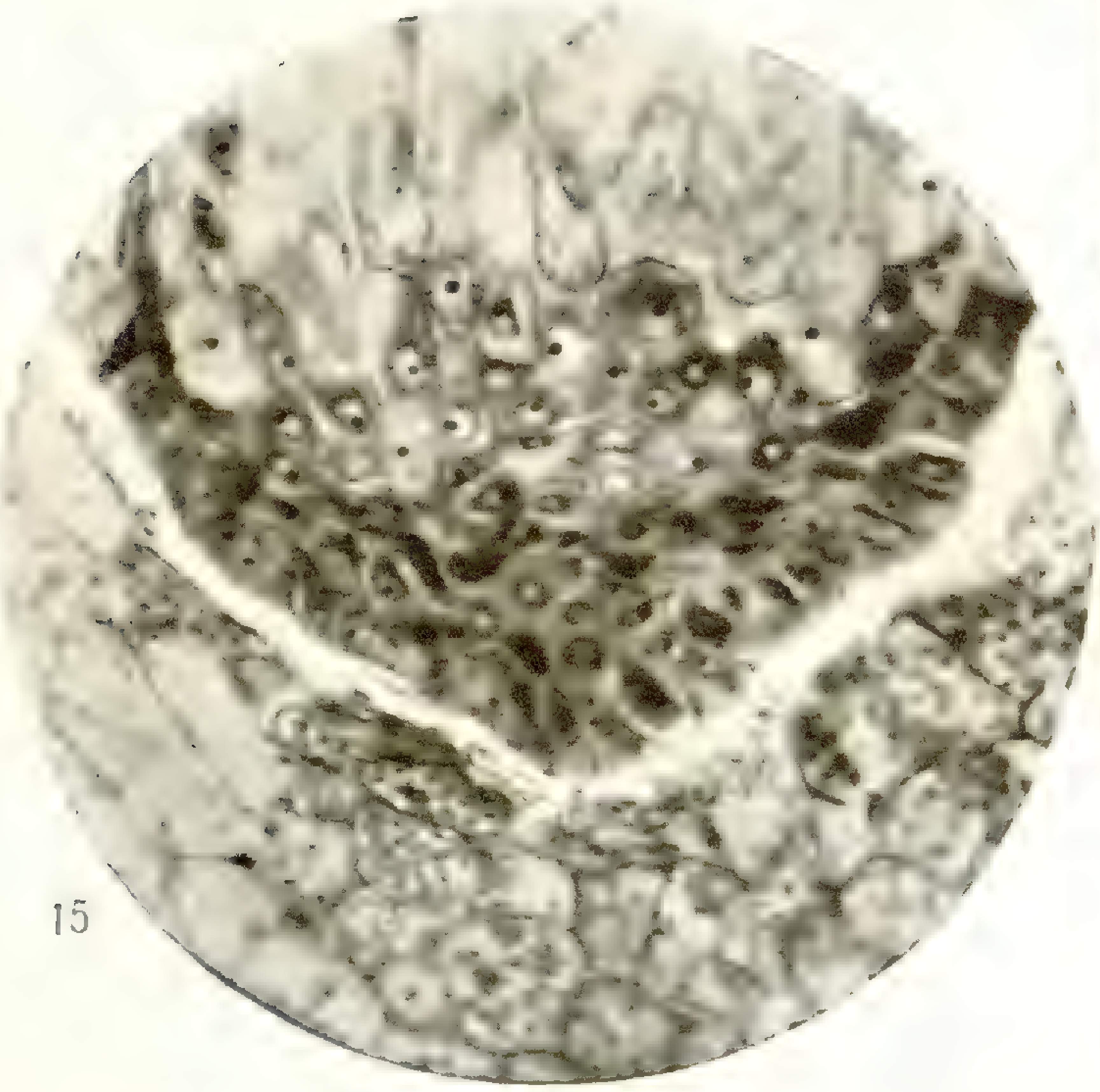

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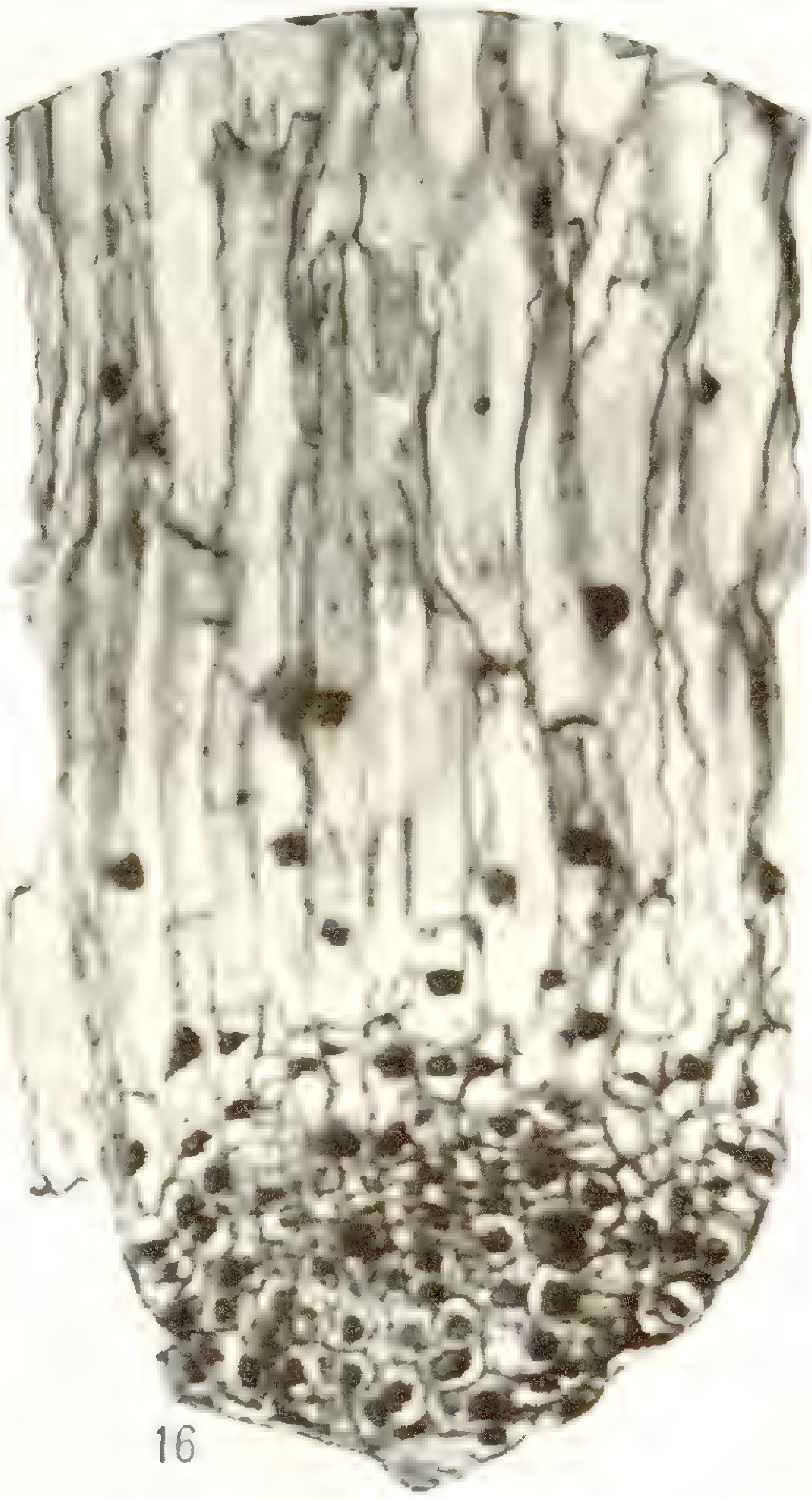

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COULTER and CHAMBERLAIN on ZAMIA

SOME TALUS CLADONIA FORMATIONS.

BRUCE FINK.

(WITH FIVE ILLUSTRATIONS)

During the summer of 1897, while studying the lichen flora of the north shore of Lake Superior, the luxuriance of certain lichens growing on talus attracted attention. The field work was being done for the Minnesota Botanical Survey, and an illustration of one of these unusually large lichens, a cluster of *Cladonia rangiferina* two and one-half feet in diameter and standing fully ten inches high, has already appeared in *Minnesota Plant Life*. During the summer several talus lichen societies were hastily examined, and it soon became apparent that luxuriant growth is by no means the only interesting feature of such plant societies. The object of the survey was taxonomic rather than ecologic, and in a field where many of the lichens were new to the writer, it was found to be practically impossible to secure the data necessary for a study of ecologic problems without seriously interfering with the main object of the expedition. Not until the summer of 1902 was it again found possible to visit the region and secure the desired data. Of course the tali studied in both years all lie within the state of Minnesota. During the season of 1897 tali were observed and somewhat studied along the international boundary between Grand Portage and Gunflint, and farther south at some distance inland in the Misquah Hills, as well as in the Sawteeth Mountains along the shore of Lake Superior. In 1902 efforts were confined to the region along the lake shore, an area not easily equaled in interest as to lichen flora.

On the whole it may be said that such talus lichen societies as will be considered in this paper are among the most interesting of lichen communities. Yet it must be added that they are quite as rare as interesting, or that, growing where they are very difficult of access, they are rarely seen. The composition of such lichen societies varies with surrounding ecologic conditions. The most apparent of determining factors are the age of the talus, amount of light, shade, and moisture, nature of surrounding vegetation, and edaphic conditions respecting presence or absence of humus upon the lichen-bearing rocks. The age of a given talus is by no means an easy matter to determine. The tali bearing the plant societies under consideration are all surely postglacial, for the old shore lines of Lake Superior extend to or above their bases. So much for a maximum age; now for a minimum. The writer does not know of any igneous or metamorphic rocks, such as those bearing the lichen societies now under consideration, exposed within the last quarter of a century and bearing any considerable number of foliose or fruticose lichens, if indeed any kind whatever. Lichens do take possession of burned-over ground and old stumps to some extent in half the time indicated above, but not the more resistant rocks. Relative age of tali may of course be ascertained to some extent by the age of the trees found growing upon them; but lichens do not gain a foothold on the hard Algonkian rocks rapidly, and the changes in lichen population go on so slowly that little can usually be learned as to exact time involved in the establishment of the lichen population of a given talus. However, tali may be found that are comparatively very young and totally devoid even of the pioneers among rock-inhabiting plants, the crustose lichens; and every gradation of course may be found between this condition and old tali so overgrown with trees and covered with mosses, lichens, and humus that the talus blocks are in places not easily detected. These old tali, for reasons stated elsewhere in this paper, support lichen societies composed for the most part of foliose lichens or fruticose forms, especially the Cladonias, and more commonly these fruticose species in ombrophytic associations. Thus relative age, really of greater interest in ecologic consideration of such slow-growing plants as lichens than absolute age, may be easily ascertained for lichen societies growing upon tali whose conditions as to light or shade, moisture, and surrounding vegetation are similar.

In the field work it was not possible, in the limited time, to examine a large number of tali. Consequently, three tali bearing quite different Cladonia-formations, growing under different ecologic conditions, were selected for special study.

The first lichen society to be considered in this paper may be designated as a *Cladonia gracilis formation of shaded talus*, and the second and third may be appropriately called *Cladonia rangiferina formations of shaded talus.* The two types are quite dissimilar, as in the first one finds *Cladonia gracilis* and other smaller Cladonias prevailing to such an extent as to be the only small plants to attract the notice of a casual observer; while in societies of the second type *Cladonia rangiferina* and other large closely related Cladonias are, at least on certain small and apparently rather young tali, even more predominant. In some localities, as on the north side of Carlton Peak, may be found tali bearing Cladonia-formations containing both the large and the small Cladonias in about equal proportions. The causes of the differences in composition of these Cladonia-formations are not always easy to trace. Under like conditions as to substrata there may be a succession, the larger Cladonias following the smaller, but quite as often species of Cladonia seem to follow the crustose or the foliose lichens, some species of which disintegrate the rocks sufficiently to form a beginning of humus on which the Cladonias may become established. In instances of this kind the Cladonias that gain a foothold may be the larger or the smaller species according to surrounding ecologic conditions. If the lichen society is surrounded with large trees, containing a good number of conifers, and especially pines, the large *Cladonia rangiferina* and closely related species will predominate. If the trees surrounding or growing upon the talus are small, and especially if devoid of conifers, the smaller *Cladonia gracilis* and other small Cladonias will prevail. If trees are growing upon the talus, of course they are younger than the talus on which they grow, and relative age of such tali may be estimated somewhat accurately by the size of the trees growing upon them. The talus on Hat Point at Grand Portage, to be mentioned again, estimated thus is the oldest one, and the one at Howenstine Bluff (*fig. 1*), to be considered later, is the

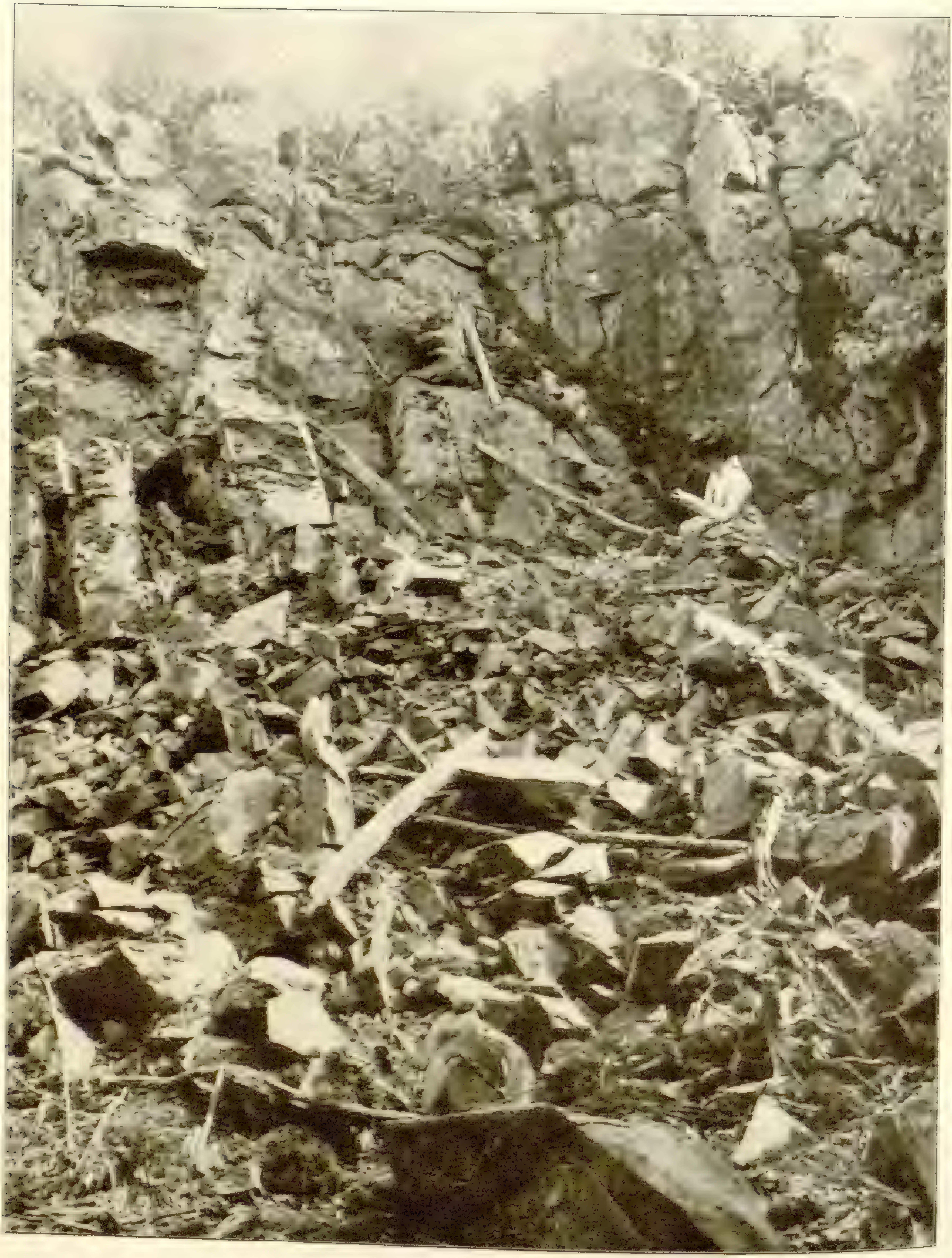

FIG. 1—General view of a portion of the talus and face of Howenstine Bluff taken from a point just below the tree line, showing talus blocks, old logs, more or less of the lichens growing over them, and shrubs and trees in various positions.

youngest of the lichen-bearing tali studied. Of course fires have run over certain tali and destroyed the plant life. In such instances the age may, for our purpose, be estimated from the time when the fire destroyed the lichens and other plants; for we are really interested in the age of plant societies.

On the old talus at Hat Point the lichen clusters, in the more shaded spots, are being driven out by the mosses, and the lichen-formation may be said to be scattered.[1] Yet the Cladonias of such societies are the most luxuriant known to the writer. On the tali which seem younger, or which do not present quite so purely ombrophytic conditions, the lichens occupy nearly the whole of the surface. The last formation to be considered below is such a one. Before passing to consider the individual formations it may be well to state that the Cladonias are found so densely congregated upon certain tali because better adapted to the environment than other plants, with which they cannot cope so successfully in the surrounding woods, though the lichens of the tali occur more or less commonly in the woods also. Further it may be said that these Cladonia societies of the tali always attract notice and special interest.

Passing to the consideration of the formations, the one that has been designated the *Cladonia gracilis formation of shaded talus* may be taken up first. The lichen society of this type to be considered especially occurs upon the talus on the north side of Howenstine Bluff, about a mile west of Grand Marais Bay, at Grand Marais, and is the best example of such lichen society known to the writer. The bluff faces to the north and rises forty-five feet above the level ground at the base to the northward. The lower two-thirds of the face of the bluff is covered with talus blocks of various sizes, and the face of the talus rises at an angle of about 35°. The base of the talus lies about forty feet away from the base of the bluff face, and fully one-third and in some places half way up from the base the talus is covered with a more or less dense growth of trees of moderate size, whose branches overhang the talus rather more than half way up to the bluff face. Thus taking into account both the trees and the north exposure of the bluff face, the sun can shine upon the talus not more than an hour or two each day. Further, partial shade is afforded by a line of shrubs, six to ten feet high, growing along the bluff face at the top of the talus (*fig. 1*). The face of the bluff above the talus is covered with species of Stereocaulon, Cetraria, Ramalina, Buellia, Usnea, Lecanora, Alectoria, Evernia, and Pannaria, while the talus below is covered with a perfect maze of Cladonias and mosses, with species of Stereocaulon, Peltigera, Sticta, and Parmelia interspersed here and there. The Cladonias have doubtless wandered to the talus from the level woods to the north below and yet more from the south on top of the bluff, and are especially numerous as to individuals and species because such an ombrophytic habitat is well adapted to the development of lichens having erect podetia surrounded by a protective pseudo-cortex of densely interwoven hyphae. These podetia are of course through the cortical hyphae protected against too rapid evaporation of moisture, and thus the Cladonias are able to rise from the substratum in a more or less erect position and successfully compete with the mosses for possession of the talus blocks.

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[1] FINK, B., Minnesota Botanical Studies **2**:300. 1899.

The species and varieties easily detected in an area of the talus one rod square are *Cladonia gracilis*, *C. gracilis dilatata*, *C. cristatella*, *C. verticillata*, *C. verticillata evoluta*, *C. furcata paradoxa*, *C. fimbriata*, *C. fimbriata apolepta*, *C. fimbriata subulata*, *C. fimbriata radiata*, *C. bacillaris*, *C. deformis*, *C. pyxidata*, *C. cenotea*, *C. coccifera*, *C. squamosa*, *C. caespiticia*, *C. uncialis*, *C. rangiferina*, *C. sylvatica*, and *C. alpestris*. Of these the first and its variety (*fig. 2*) are especially abundant, though all but the last half-dozen are common enough. From the tree line to the base the talus is literally covered with Cladonias, of which the one for which the formation is named predominates even more largely than on the portion of the talus above the tree line. On this lower shaded portion of the talus, the Cladonias grow most abundantly on the old logs that cover the greater portion of the base of the talus. Unfortunately, it was found necessary to remove a few of the trees, shrubs, and logs growing upon

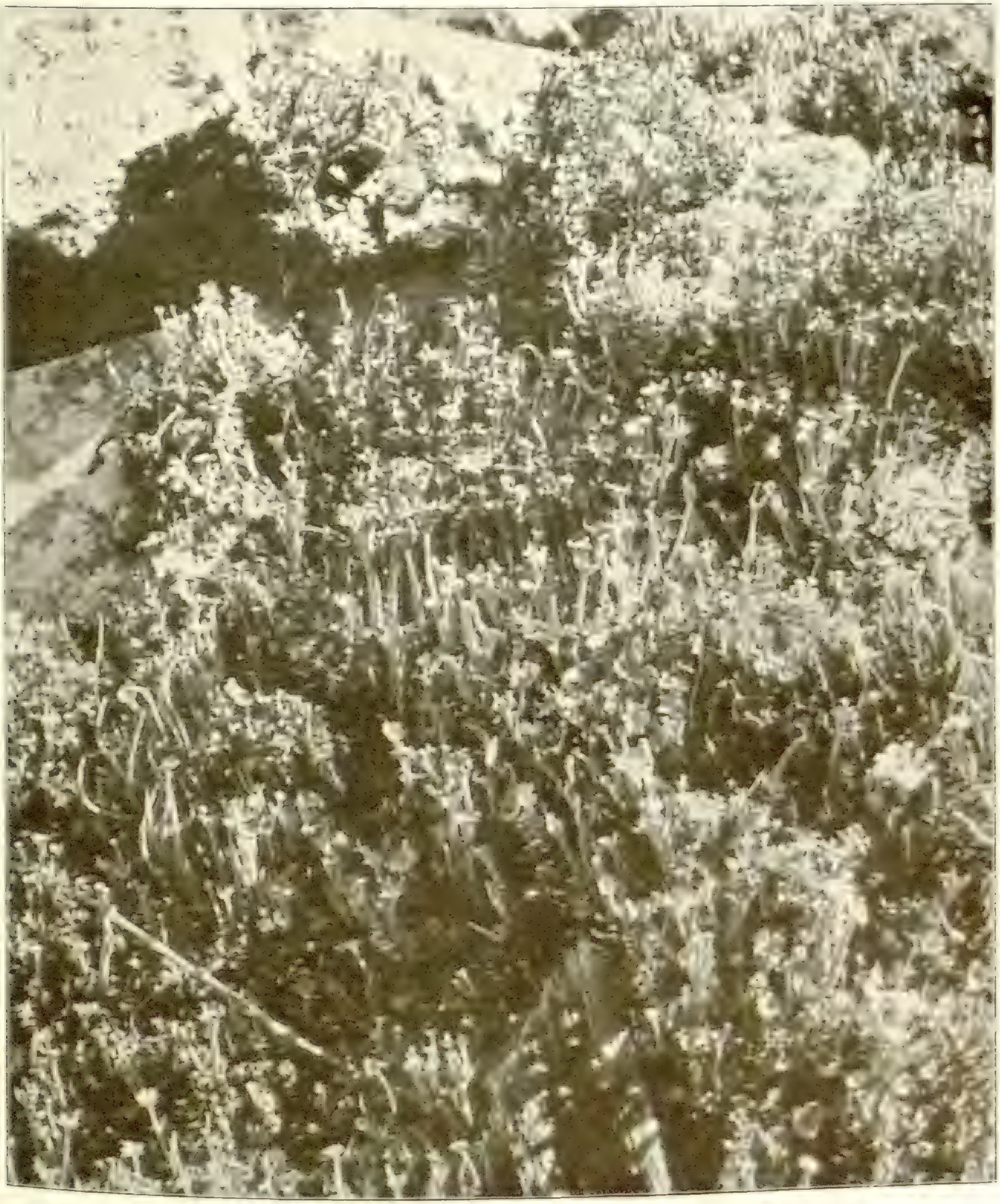

FIG. 2.—Detail of an area of the Howenstine talus one foot square, taken just above the tree line and covered with a dense growth of the most conspicuous plant of the society, *Cladonia gracilis*, and eight or nine other Cladonias in small numbers.

the talus to get a good general view, and it may be said that the presence of old logs upon the talus is an ecologic factor of considerable importance, as these smaller Cladonias are usually abundant on and about such decaying logs in favorable habitats.

It is an interesting fact that such societies of the smaller Cladonias are usually found in regions recently burned over, while those containing the large *Cladonia rangiferina* and its allies are more common in regions not recently burned and containing large conifers, especially pines. There is good evidence that the *Cladonia gracilis* societies may become established in soil-covered burned areas in ten or fifteen years, and the name, *Cladonia gracilis formation*, may be applied to other lichen societies than those of the talus. Frequently, however, the less conspicuous *Cladonia cristatella* or *Cladonia verticillata* predominates in these societies of the soil-covered areas. Finally, it is reasonable to suppose that much longer time would be required for such a plant society to become established upon the talus than upon the soil.

Cladonia rangiferina and its allies are frequently seen wherever conifers grow in the region, but nowhere else in such abundance or luxuriance as on the shaded tali. Botanists have frequently noted the fine Cladonias of Isle Royale in Lake Superior eighteen miles east of Grand Portage, Minn. I have not seen Cladonias growing on tali on the island, but have examined them somewhat under the conifers along the shore line and have seen none equal in size to those of the tali in the Sawteeth Mountains. The writer has studied these somewhat carefully and has found them best developed at Grand Portage and Grand Marais. The *Cladonia rangiferina* formation is best developed on the east side of Hat Point near Grand Portage. The point is about one hundred rods wide at the landward extremity and extends out into the lake somewhat more than a mile, in a southeastward direction, to a lakeward extremity which is only four or five rods wide. To the landward end, Mount Josephine rises about 800 feet above the lake, and from Mount Josephine to the lakeward end the point gradually decreases in elevation as well as in

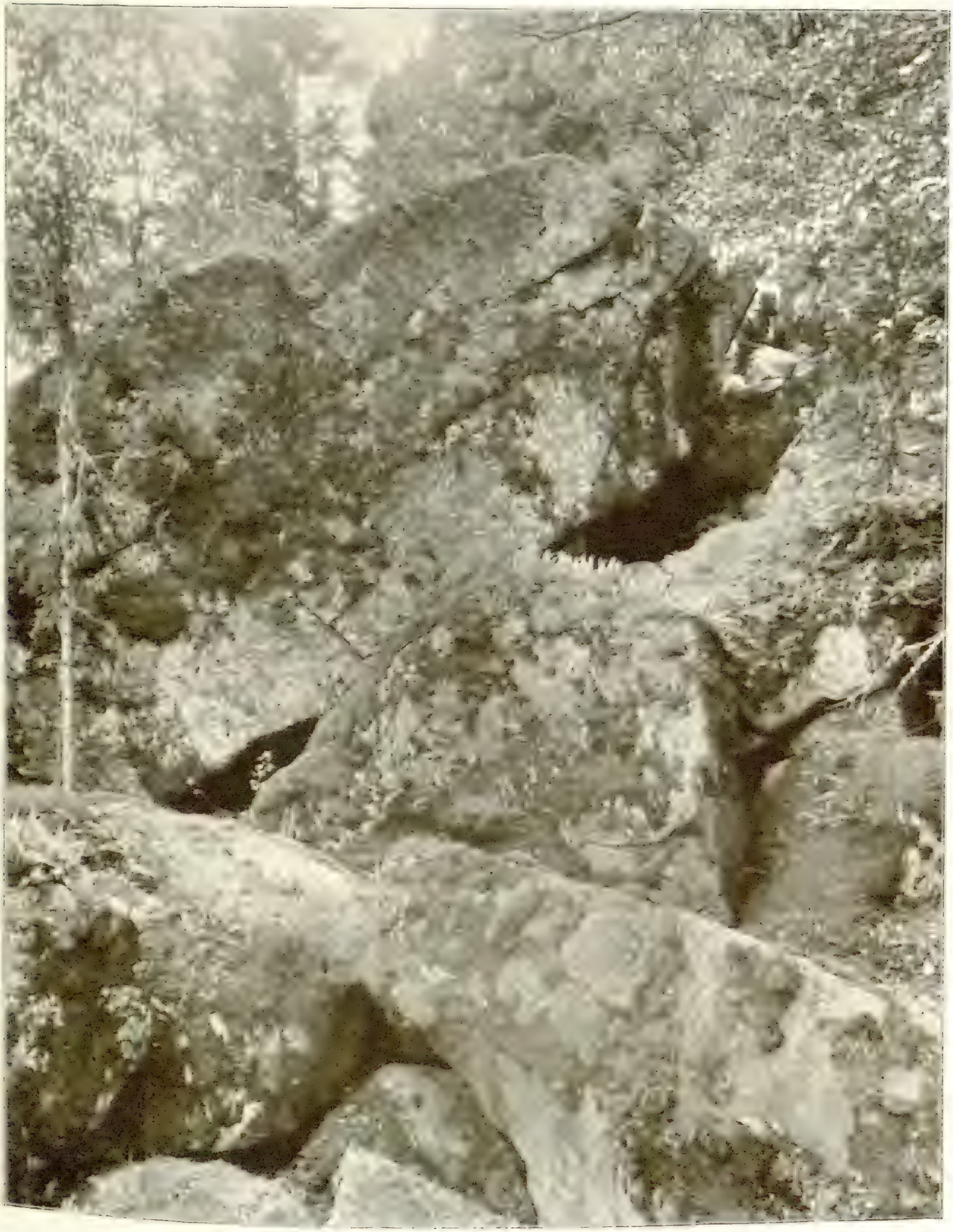

FIG. 3.—A cluster of *Cladonia rangiferina* nearly three feet in diameter, taken from the Hat Point talus. A portion of a cluster of *Cladonia alpestris* is also prominent in the figure.

width. The ridge of the series of hills extending from Mount Josephine to the extremity of the point lies to the northeast of the central axis of the point so that the descent to the lake level on this side is quite precipitous. A large portion of this northeast side is covered with talus blocks, some of which are twenty-five to forty feet in their longest dimension (*fig. 3*). These blocks are overgrown with a forest of good-sized trees, principally conifers, and the whole talus-block floor is covered with such a growth of lichens and mosses as one seldom sees. During the first visit to the spot in 1897, fields of the larger Cladonias were found which looked at a distance much like the usual illustrations of coral forests. As nearly as I can recall, one such field covered more than an acre. It was almost completely covered with magnificent clusters of *Cladonia rangiferina*, *C. alpestris*, *C. sylvatica*, *C. uncialis*, and *C. amaurocraea*, and formed as beautiful and attractive a lichen community as one can well imagine. Some idea of the luxuriance of the plants may be had when it is stated that clusters were frequently seen from two to three feet in diameter (*fig. 4*). The talus with its great blocks, frequently thirty or forty feet long, and holes between, often twenty or thirty feet deep, is not easy to traverse, and it is not strange that in two days spent on the point in 1902 this wonderful Cladonia forest was not seen. At certain points the perpendicular rock face still remains above the talus and is in places from 100 to 200 feet high. The talus with its great blocks extends from 400 to 700 feet from the ridge or the perpendicular walls above to the water's edge below.

To compensate for failure to find the field of Cladonias above mentioned, a study of a somewhat similar one, though compact instead of scattered, may be presented. This formation may well receive the same name as the one just discussed. It occurs about a mile north of Grand Marais on the south slope of the Sawteeth Mountains. The formation is most luxuriant toward the more shaded basal portion of the talus (*fig. 5*), which is about sixty feet long and rises at an angle of approximately 40°. The characteristic plants of the society are *Cladonia rangiferina*, *C. alpestris*, *C. sylvatica*, *C. amaurocraea*, *C. uncialis*, and *Stereo-*

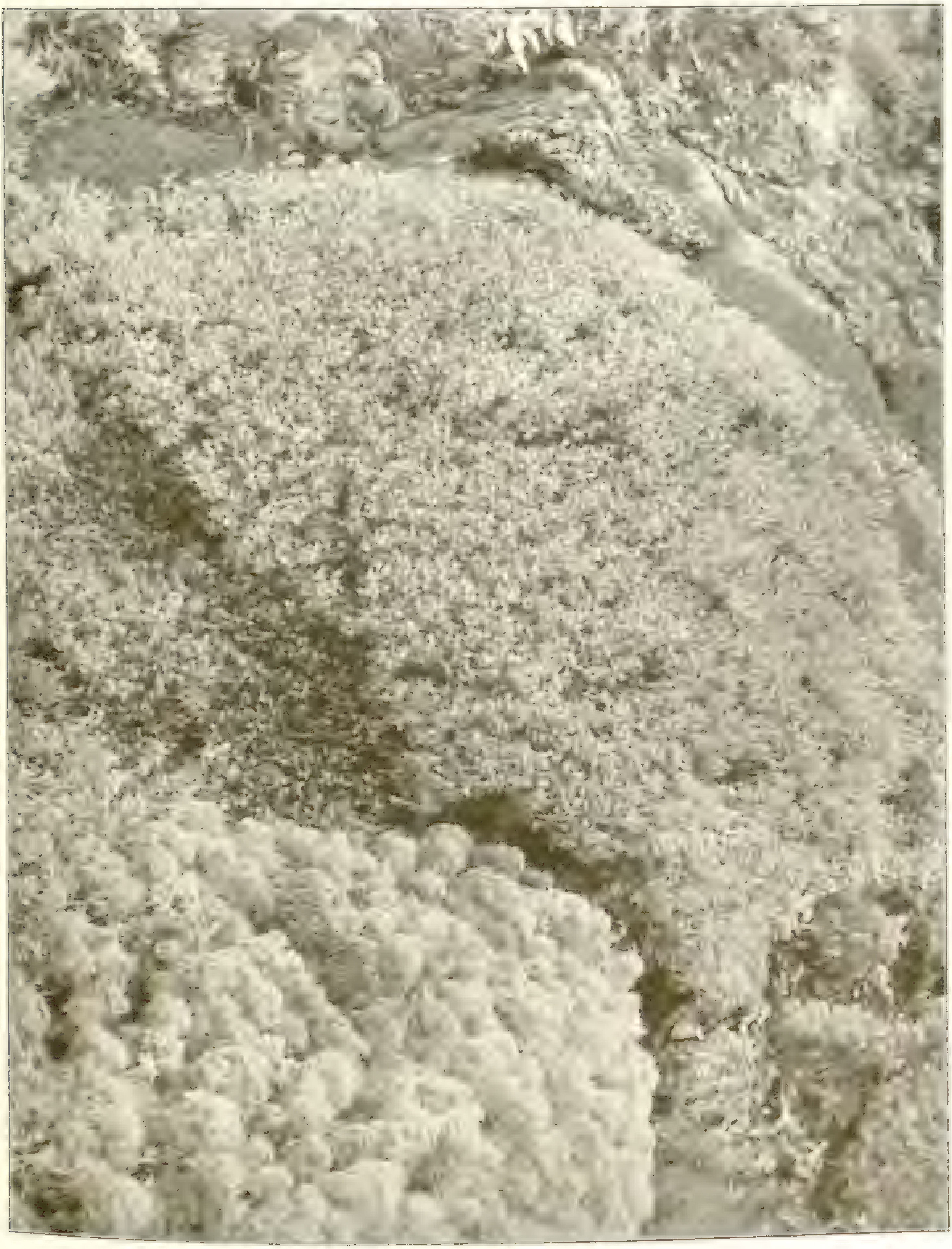

FIG. 4.—Small portion of the talus at Hat Point. The upper talus block is about 35 feet long, and its face and upper surface was found covered with Cladonias, other lichens, trees and shrubs, ferns and mosses. Cladonias are numerous on the smaller blocks in foreground.

caulon paschale. The more shaded basal half of the talus is so covered with these plants that a casual observer would scarcely notice the smaller and less numerous plants of the community. Yet a little closer observation brought to light a few ferns, quite a sprinkling of mosses, a half-dozen species of smaller Cladonias, and a few species of the foliose Nephroma, Peltigera, Parmelia, and Umbilicaria. On account of the less shaded conditions toward the upper part of this southward exposed talus, the Cladonias characteristic of the society are there less numerous and give way in part to the above-named foliose lichens and a number of species of the crustose Lecanora, Biatora, Buellia, and Lecidea. The talus sloping to the south is not, as hinted above, well shaded toward the upper part where the limbs of the large trees growing upon the lower part do not overhang. Of course the trees above a talus with south exposure do not furnish any considerable amount of shade. Consequently, rock decay has not gone on so rapidly toward the top of the talus, and neither this condition nor the lack of shade has been so favorable for the development of the erect-growing Cladonias. Hence there are present a large proportion of the crustose lichens upon the upper portion of the talus, these plants, in their closely adnate position upon the rocks, being better adapted to the more exposed portion of the talus because they easily hold the moisture between their lower surfaces and the rocky substratum and also readily absorb moisture from the rocks. The size of the trees would indicate that this talus is older than the one first considered and about two miles distant, and whether this is true or not, there is every indication that a fire ran over the one at Howenstine Bluff at no very distant day and killed the plant life of the spot so that the present growth is comparatively recent. The presence of a good sprinkling of old woody débris upon the talus now under consideration (*fig. 5*) shows that this condition alone does not indicate the presence of a Cladonia society composed of the smaller species. In this instance doubtless the *Cladonia rangiferina* society has succeeded the *Cladonia gracilis* community as the trees became larger, furnishing more ombrophytic conditions, and as the poplars and other deciduous trees

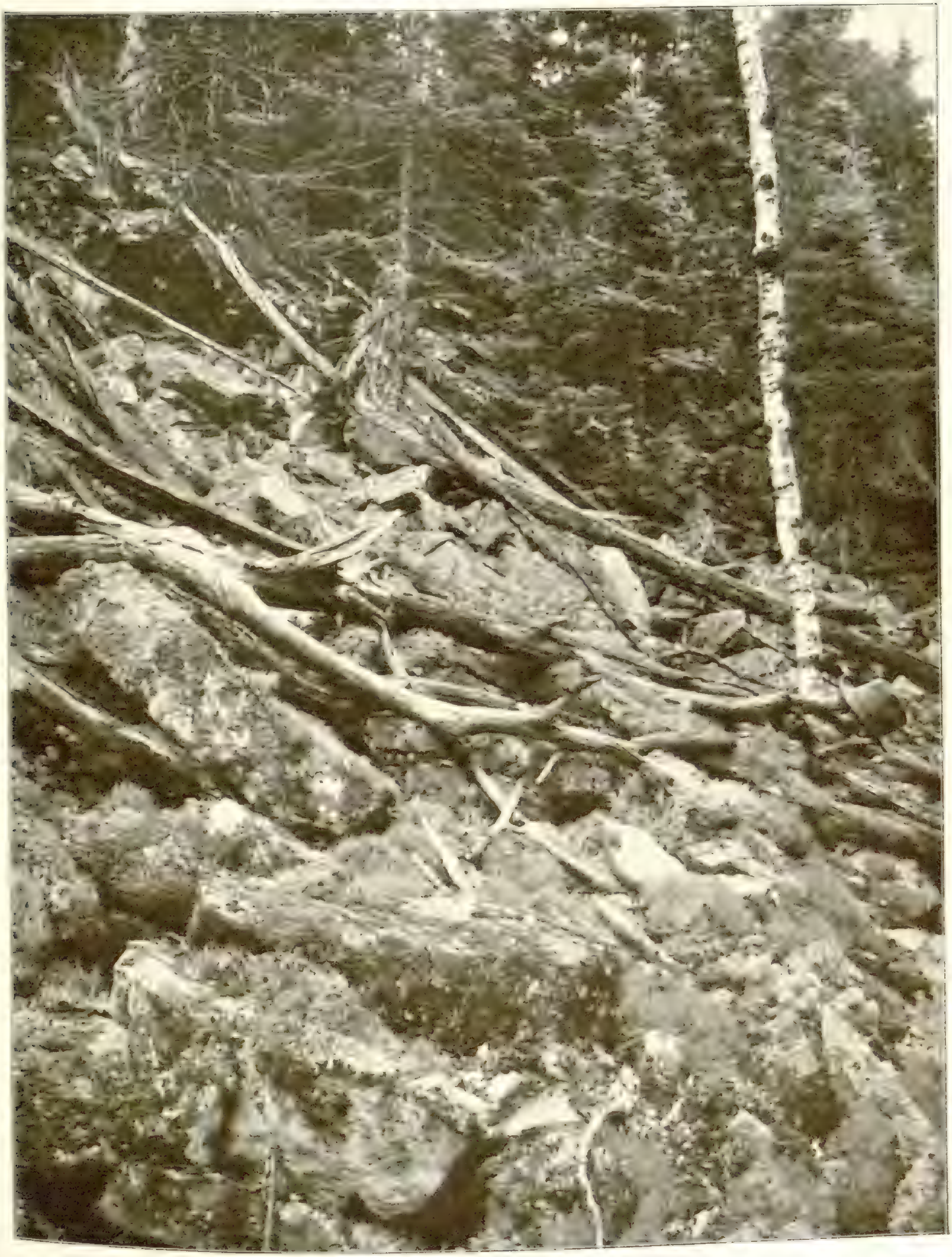

FIG. 5.—View of the talus on Sawteeth mountains, taken from a point 25 feet above the base of the talus and just above the tree line. Cladonias are conspicuous in the foreground.

gave way to a large extent to conifers, especially pines and cedars. In addition to the ecologic factors already noted, it may be said that protection from wind is a factor aiding in the development of the *Cladonia rangiferina formations*, as the plants of such societies can hardly endure the effects of strong winds.

It may be readily inferred from certain statements in this paper that it is by no means the intention to convey the impression that the Cladonia lichen societies are the only ones to be found upon tali. Other talus lichen communities, though not so striking in appearance, would doubtless prove to be quite as interesting if studied in detail. Such lichen societies as have been considered in the present paper doubtless occur in various portions of North America, especially in mountainous regions, and comparative studies as to ecologic conditions, adaptations, and species contained in the formations in various portions of our territory would be both interesting and instructive.

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Fayette, Iowa.

BRIEFER ARTICLES

THE DEVELOPMENT OF THE MACROSPORANGIUM OF YUCCA FILAMENTOSA.[1]

Considerable attention has been called to the species of Yucca on account of the curious symbiotism existing between them and the moth (*Pronuba yuccasella*) which is the principal agent in pollinating the stigma (5, 15). The very complete studies of Riley, Trelease, Engelmann, and others have related to the process of pollination by this moth and the parallel life-histories of the two organisms. My work has been on the embryology of *Yucca filamentosa* L., and the present paper treats of the development of the macrosporangium. In many points its development does not differ from that of the other Liliaceae which have been the subject of so much embryological research; but there are certain interesting deviations which may or may not be a result of the curious life-history of the plant.

The material used was collected in the summer of 1900 from plants growing in the botanical garden of the University of Michigan, and was fixed in Flemming's weaker killing fluid and in Worcester's killing fluid.[2] The ovaries were imbedded in paraffin, sectioned, and stained upon the slide. The haematoxylin stains of Kleinenberg and Haidenhain and picro-nigrosin were very satisfactory stains for nuclear study, while Zimmermann's fuchsin-iodin-green was the best for general cytological study. I wish here to acknowledge my indebtedness to Dr. James B. Pollock for criticisms and suggestions.

The anatropous macrosporangia are arranged in six vertical rows, two in each chamber, arising in acropetal succession from a ridged placenta. A hypodermal cell is early differentiated in the apex of each macrosporangium, from which two kinds of cells later originate.

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[1] LXV. Contribution from the Botanical Laboratory of the University of Michigan.

[2] As I am not aware that the formula for Worcester's killing fluid is familiar to cytologists, I give it, as follows:

Mercuric chlorid, saturated aqueous solution	90 parts
Formalin (40 per cent. formaldehyde)	4 "
Acetic acid 10 per cent.	10 "
Formic acid to each liter of solution	5 drops

Wash in 70 per cent. alcohol.

It soon divides by a periclinal wall, forming a primary tapetal cell and a sporogenous cell. The primary tapetal cell subsequently divides by two anticlinal walls at right angles to each other, forming four (rarely two) tapetal cells which closely resemble the reproductive cells in size, contents, and staining qualities (*figs. 1, 2*). Other investigators (4, 11) have noted similar processes of division in monocotyledonous plants. The sporogenous cell, by two divisions, forms an axial row of four potential macrospores; frequently these divisions occur by walls all of which are perpendicular to the long axis of the ovule (*fig. 1*), but more often the walls between a_1 and a_2 are parallel or oblique to the axis of the ovule (*fig. 2*). So far as I know, no case has been reported where four potential macrospores have the arrangement shown in *fig. 2*.

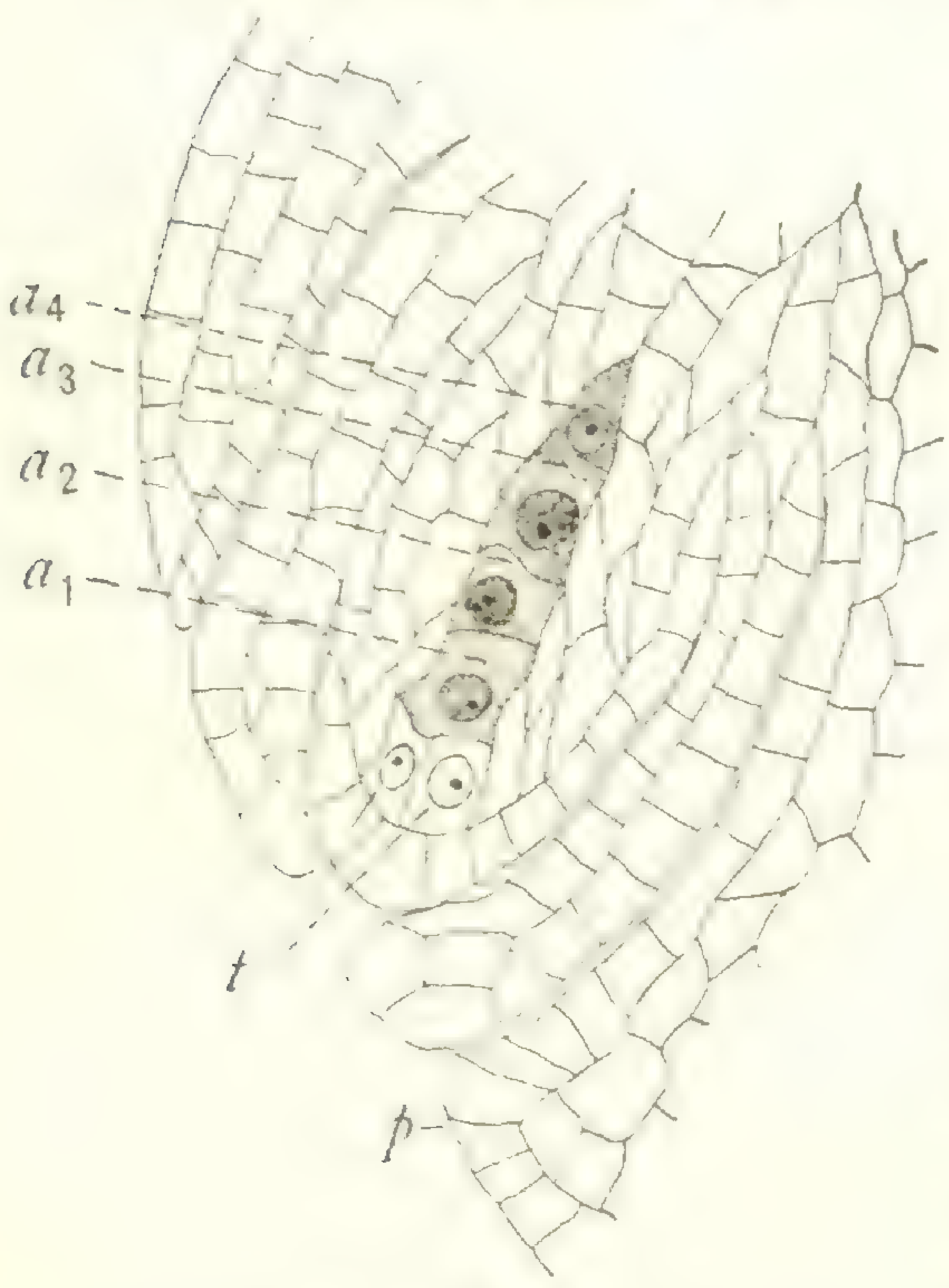

FIG. 1.

An axial row of four macrospores has been reported in a number of plants, some of the best-known cases being the Gramineae (3), many of the Rosaceae (1, 14), Elodea, Triglochin, Carex, Polygonum (3), Avena (9), Canna (11), Eichhornia, Pontederia (8), and probably in *Potamogeton natans* (12) and *Lilaea subulata* (7). Three macrospores occur in Orchis (1, 14), Allionia, Gomphrena, Geum (3), Naias and Zannichellia (6), two in *Convallaria majalis, Potamogeton foliosus* (11), and *Arisaema triphyllum* (4), except that in the last named they stand side by side instead of forming an axial row.

When the wall between a_1 and a_2, *fig. 2*, is nearly parallel to the plane of the section the axial row appears to have only three macrospores, but careful focusing shows that a_1 and a_2 lie one above the other. The cell at the basal end of the row is usually triangular.

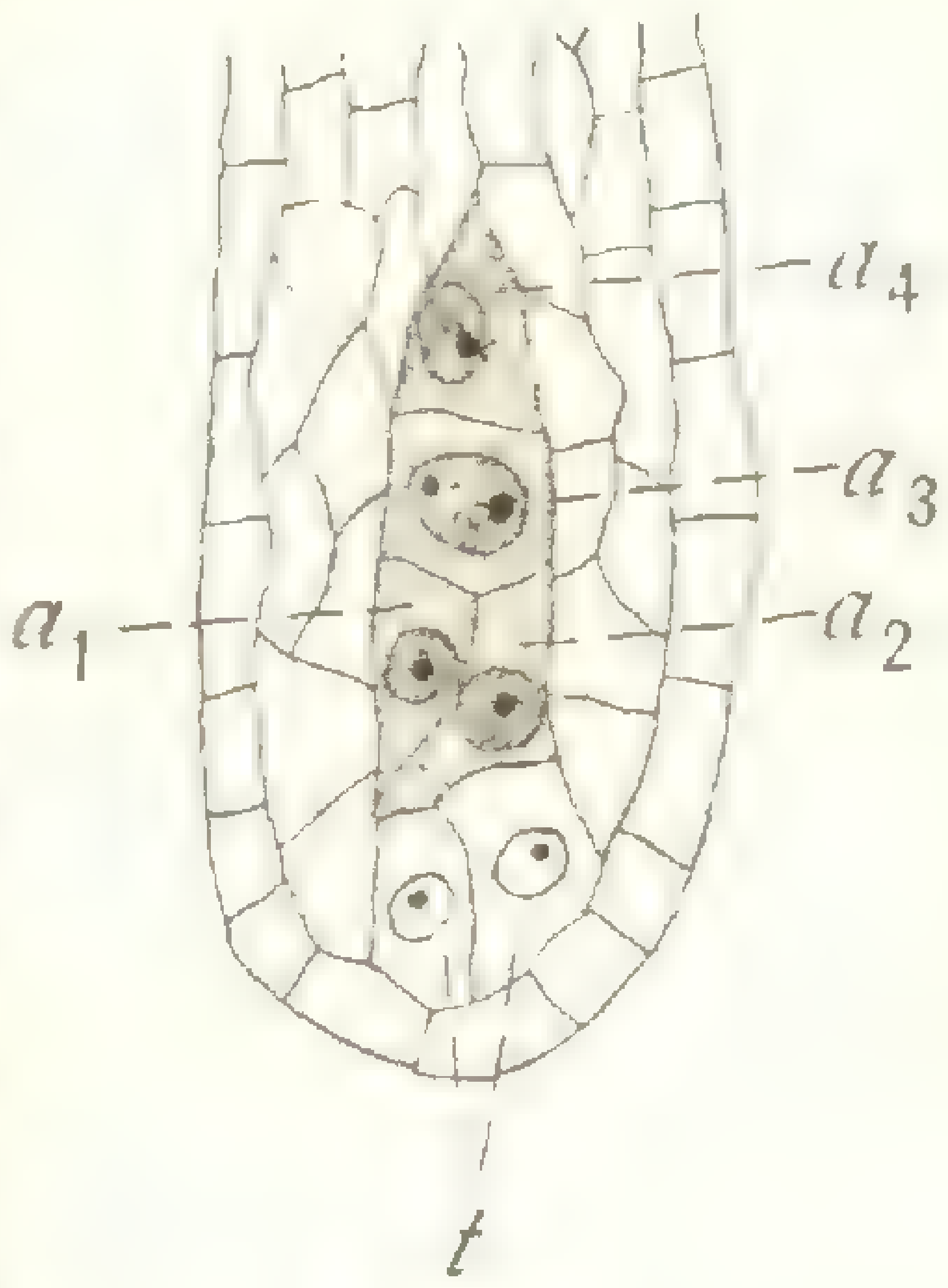

FIG. 2.

Three of the cells of the row disintegrate. The survivor becomes the embryo-sac. There are indications that any one of the four macrospores may become permanent, but in every case where I could be certain, a_3 was the nucleus which matured. Zimmermann's fuchsin-iodin-green was a very valuable stain for differentiating the reproductive nuclei from the vegetative nuclei, making it possible to distinguish the two with certainty. The cell which becomes permanent is often larger than its sister cells from an early stage; as it enlarges further, their walls break down and their contents are absorbed, leaving the macrospore in a long pointed cavity in the middle of the nucellus. The process resembles that described by Strasburger (1) in *Polygonum divaricatum.*

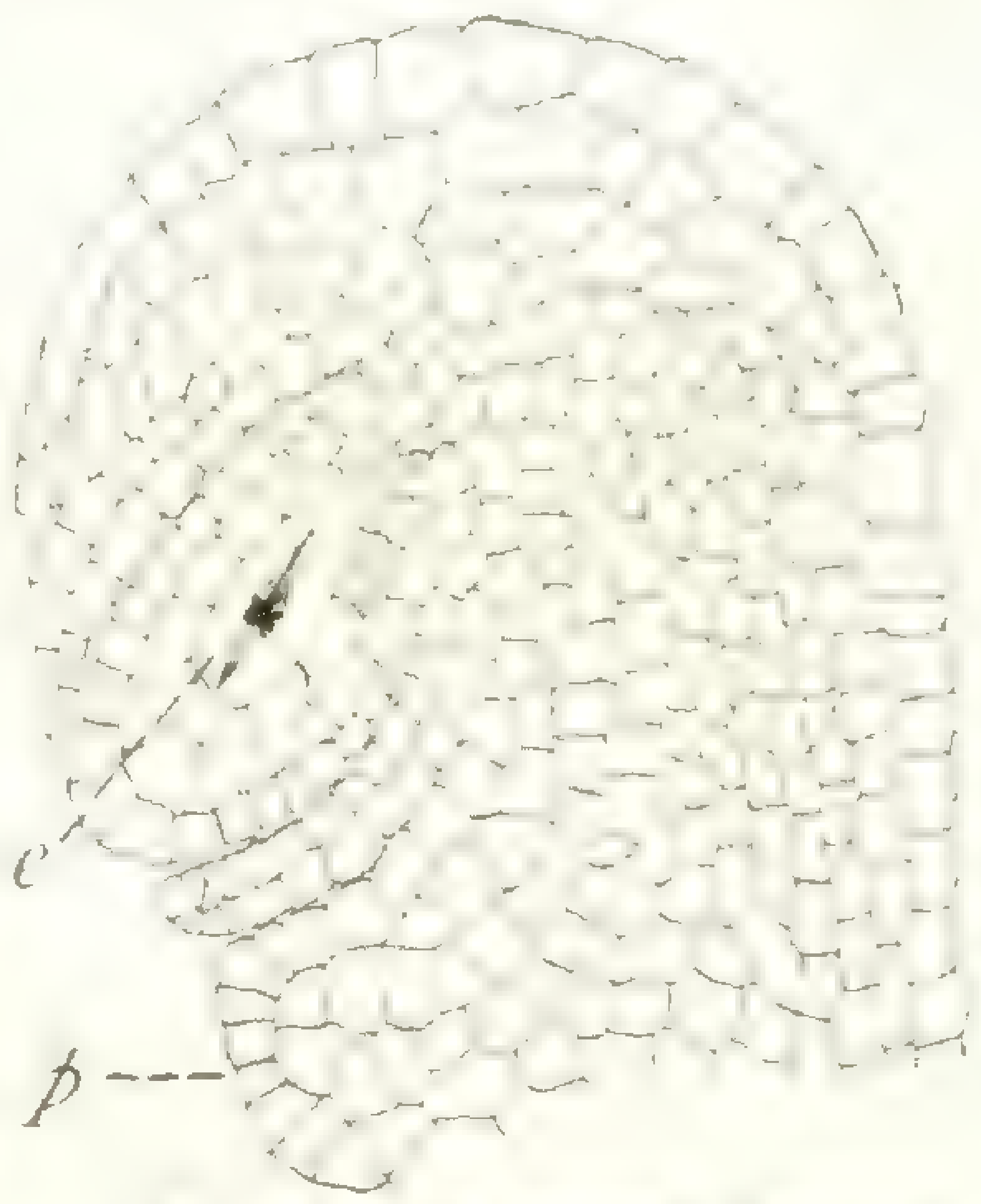

FIG. 3—A young macrosporangium at the time of the formation of the haustorial tube: *e*, embryo-sac mother cell; *p*, placenta. ×360.

The development of the macrosporangium in *Yucca gloriosa* has been worked out by Vesque (2), who described a hypodermal cell which gives rise to a two-layered tapetum and three potential macrospores, but did not follow the development far enough to determine which one persisted. There is no question, in all the cases which I examined, but that *Y. filamentosa* is constant in having a single layer of tapetal cells and that such cells as a_1 and a_2, *fig. 2*, are true macrospores. The fuchsin-iodin-green stain plainly differentiates the nuclei of the different cells. When disintegration begins the three macrospores disappear almost simultaneously, followed later by the tapetal cells.

The permanent nucleus now enters upon the divisions which produce the eight nuclei of the embryo sac. *Fig. 3* represents the first division and shows the shape of the embryo-sac at that time. The subsequent divisions are accomplished in the lower, pointed end of the cavity. The antipodal nuclei are often separated from each other by distinct cell walls. By the time the sexual nuclei are formed, the tapetal cells and part of the nucellus have disintegrated, leaving the apical end of the embryo-sac in contact with the epidermis of the macrosporangium.

The embryo-sac grows chiefly in the apical part at the expense of the nucellus and tapetum. The basal portion of the sac appears to sink deeper into the nucellus by reason of the elongation of cells in its walls, but it increases in diameter very slightly. The result of this manner of growth is to produce a narrow tube which penetrates the nucellus nearly to the extremity of the fibrovascular bundle (*figs. 4, 5*). The migration of the nuclei into the tube and its relation to the fibrovascular system suggest that it may have a nutritive function, serving as an haustorium. This suggestion is further supported by the presence of fine granular material in the tube and in the cells adjacent to the fibrovascular bundles and the tube. If these are the granules of an organic acid, as their staining qualities indicate, or some form of plastic food material, then the migration of the nuclei may be considered a chemotactic response analogous to the growth of the pollen tube and the entrance of the antherozoids into the embryo-sac. Vesque (**2**, p. 304) found haustorial appendages in the embryo-sacs of Scrophulariaceae, Santalaceae, and Lathraea, and comments upon the parasitic nature of the embryo-sac in certain instances. A recent writer (**13**) reports the presence of haustorial appendages in certain of the Araliaceae.

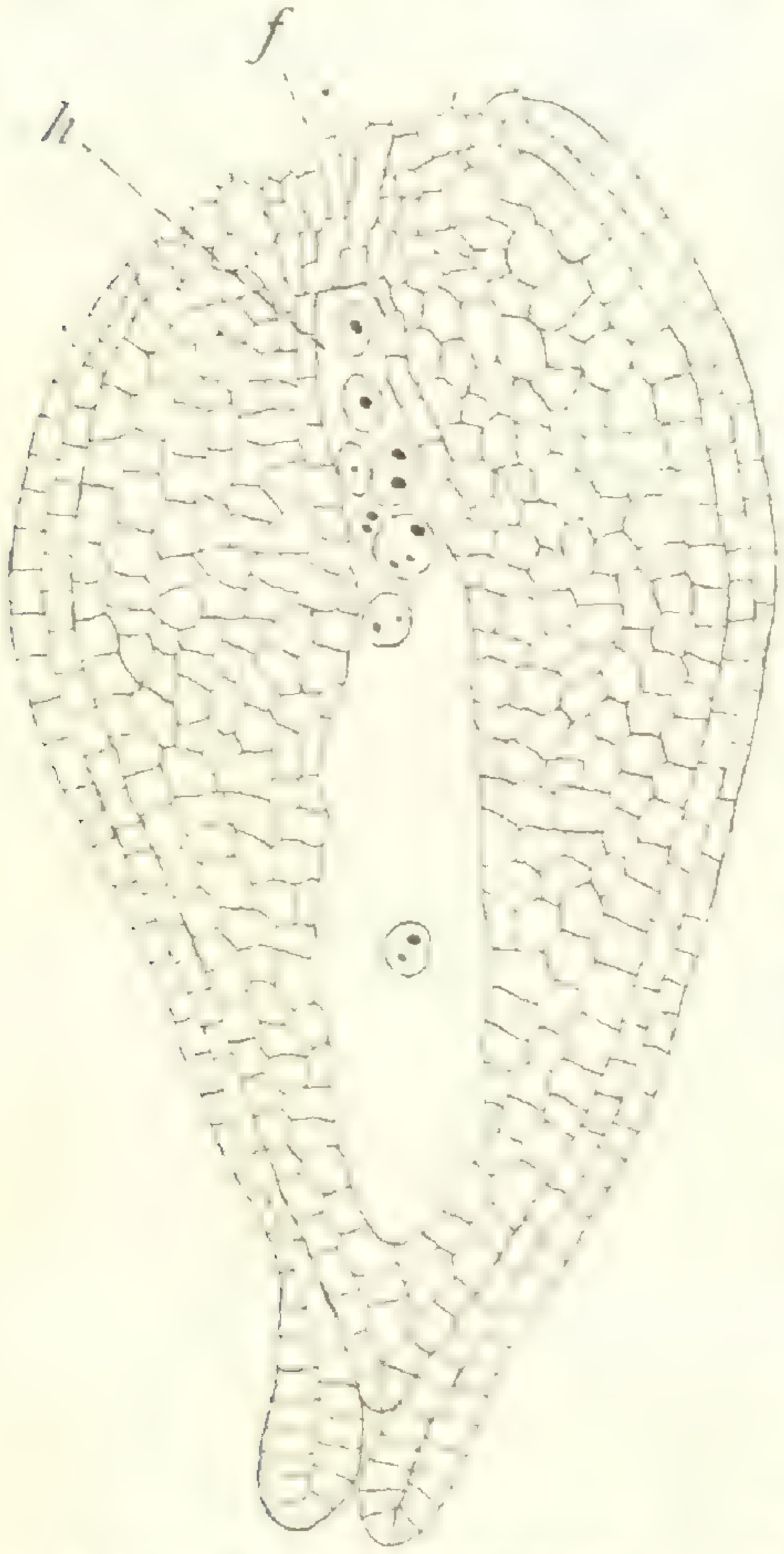

FIG. 4.—An embryo-sac in which the haustorial tube is fully formed and the divisions of the macrospore are completed: *f*, fibrovascular bundle; *h*, haustorial tube. × 360.

After the divisions of the macrospore are completed, the egg-cell and synergids move up to the apical end of the embryo-sac; the definitive nucleus also moves out, but often only to the mouth of the haustorial tube, sometimes to the middle of the embryo-sac; the antipodal nuclei usually remain in the tube.

Coincident with the divisions of the macrospore and formation of the embryo-sac haustorium, there is a rapid increase in the amount of nucellar tissue, an enlargement of the embryo-sac cavity, and a preparation for fertilization.

The columnar cells which serve as an epidermis to the placentae and to the macrosporangium are very large on that part which covers the ridges of the placentae and the basal part of the stalk of the macrosporangium. From these cells there exudes a mucilaginous secretion a short time before fertilization occurs. The secretion passes outward in the cavity surrounding the macrosporangia, often forming a hood around each macrosporangium (*fig. 5*). In passing the micropyle the secretion often finds its way into it, and may force its way for some distance between the inner and the outer integuments. The question arises: Is not this an *artifact*, caused by some fault in the technique? The methods of preparing the material were varied until there was no longer any doubt as to their reliability and the identity of the secretion whenever obtained. A somewhat similar thing has been noted by Guignard (**10**) in the tulip. He speaks of papillae lining the wall of the cavity surrounding the macrosporangia, among which the pollen tube makes its way to the micropyle. Campbell also mentions the presence of secreting cells on the funiculus in Naias, but found no secretion. Wherever I have seen pollen tubes in my sections they have been growing in or toward this secretion. There is no evidence that this secretion has any distinctively nutritive function in itself, but rather that it serves as a medium through which the substance capable of attracting pollen tubes diffuses outward from the micropyle. If the colloidal secretion were nutritive, there would be an attraction of the pollen tubes into all parts of the secretion, but this is not the case.

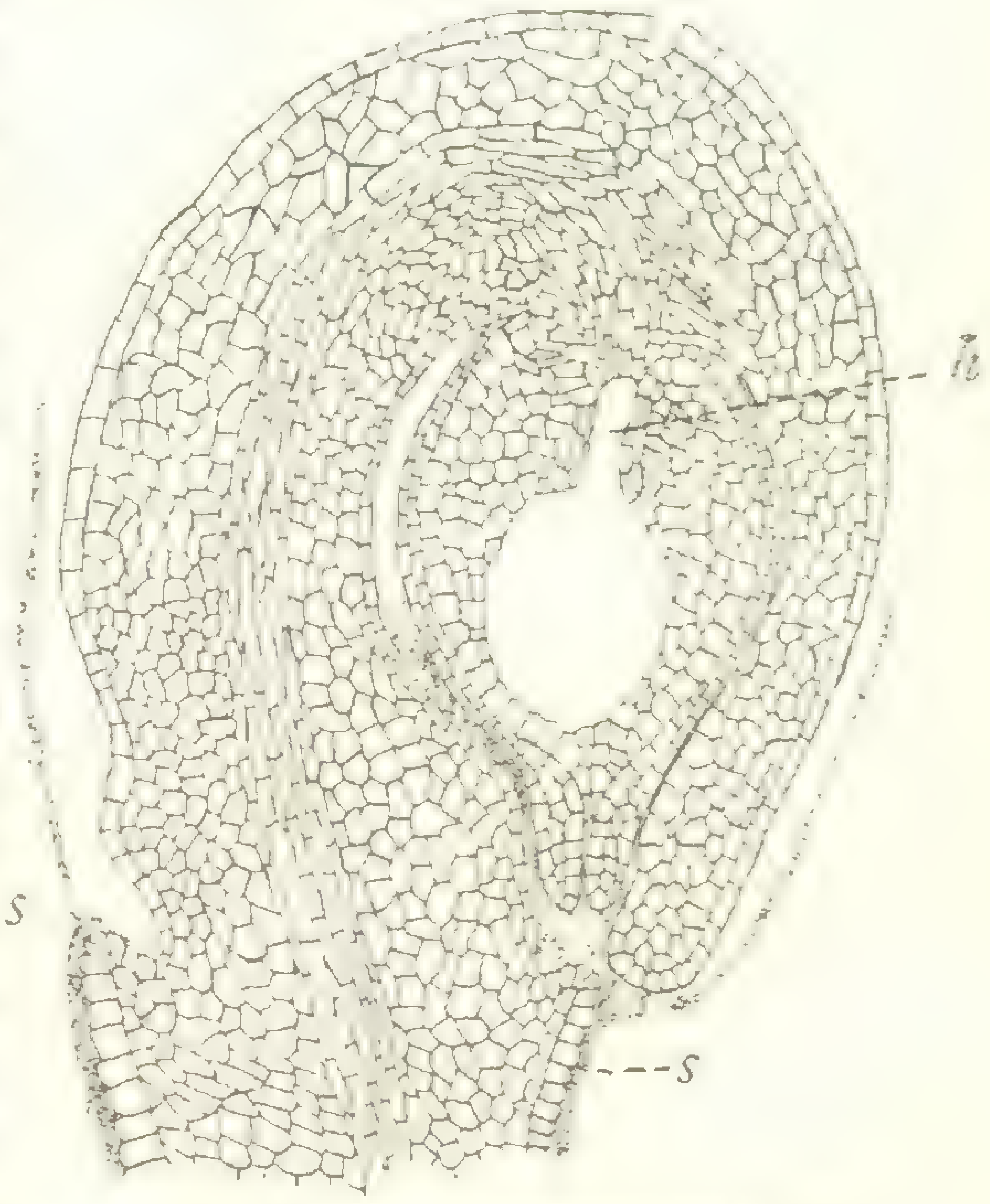

FIG. 5.— A macrosporangium at the time of fertilization: *h*, haustorial tube; *s*, secretion from placentae. × 270.

The egg cell of the embryo-sac is fertilized shortly after the formation of the secretion. The results of fertilization are several: the formation of the secretion from the placentae ceases and all which exists disappears; the small rectangular cells on either side of the haustorial tube rapidly elongate, and the embryo sac enlarges in a transverse direction.—HOWARD S. REED, *University of Michigan.*

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FAXONANTHUS.

THE January number of the BOTANICAL GAZETTE, in a review of the first part of Professor C. S. Sargent's *Trees and Shrubs*, calls attention to the fact that a new genus, *Faxonanthus*, is therein described without mention of the family to which it belongs. The author of the genus desires to say that in the transcription of the original manuscript for publication a brief note on its affinity was omitted. It may be stated that the new genus *Faxonanthus* belongs to the Scrophulariaceae, and should be placed near the genus Leucophyllum.—J. M. GREENMAN, *Gray Herbarium.*

NOTES ON NORTH AMERICAN GRASSES.

I. ANDROPOGON DIVARICATUM.

ANDROPOGON DIVARICATUM L. Spec. Pl. 1045.—This North American grass has been neglected because it could not be identified. The description is meager and misleading. The first species of Andropogon described by Linnaeus, *A. contortum*, is now referred to Heteropogon. The second species is *A. divaricatum*, described as follows:

> Andropogon spica oblonga, floribus lanatis remotis divaricatis: arista flexuosa nuda.
>
> Lagurus humilior, panicula conica laxa nutante culmum terminante. Gron. Virg. 135.
>
> Habitat in Virginia.

It is interesting to note that the *Index Kewensis* maintains the species, as Mr. Jackson had no reason for doing anything else with it. Mr. Munro in his account of the grasses in Linnaeus's Herbarium refers this to *Andropogon ternatus* Nees. Hackel in his monograph of the Andropogoneae suspects that it should be referred to *A. argyraeus* Schult., as *A. ternatus* is a South American species which Munro may have confused with *A. argyraeus*. I have recently examined the specimen of *A. divaricatum* in the Linnaean Herbarium and find that it is identical with his specimen of *A. alopecuroides* described as no. 4 of the *Species Plantarum*. The specimen, however, is quite fragmentary, consisting of a main axis with eight remote and divaricate branches, the whole forming an oblong spike about two inches long. The branches have from one to three spikelets. The plant was old, and all the others have fallen off. The spikelets are identical, however, with those of *A. alopecuroides*. In both cases the awn is twisted.

Linnaeus gives as synonym Gronovius 135. This is founded on Clayton's no. 600 from Virginia and is *Andropogon nutans* L. I examined this in the Herbarium of the British Museum where the plants of Gronovius are deposited.

The description of Linnaeus evidently applies to his own specimen rather than to Gronovius's plant. Strict application of the rules of priority would require that the specific name *divaricatum* be taken up for *A. alopecuroides*, which is an Erianthus, but as I do not wish to be quoted for such a binomial I do not make the combination. In this connection it may be noted that some botanists consider the twisted awn of Erianthus as a specific character. In Britton's *Manual* we have *Erianthus alopecuroides* (L.) Ell., but Elliott's plant has the straight awn, hence on the above-mentioned basis *Andropogon alopecuroides* L. and *Erianthus alopecuroides* Ell. are not identical. My own opinion is that these, *E. saccharoides* Michx., and *E. compactus* Nash are all forms of the same species.

The third species described by Linnaeus is *A. nutans.* The plant in the Linnaean herbarium is what we have generally been calling by that name. Two synonyms are given. The first is *Andropogon folio superiore*, etc., of Gronovius based on Clayton no. 621, which is *Stipa avenacea* L. The second synonym is *Gramen avenaceum*, etc., Sloan, Jam. 35. Sloan's plants are also deposited in the herbarium of the British Museum. His plant is *Andropogon insularis* L.

The fourth species of Andropogon described by Linnaeus, *A. alopecuroides*, is founded upon a large panicle in his herbarium and upon Gronovius Virg. p. 133, Clayton no. 601, which is the same. The third synonym is Sloan, Jam. 3. Sloan's plant I take to be a different species of Erianthus.

II. DACTYLIS CYNOSUROIDES L.

DACTYLIS CYNOSUROIDES L. Spec. Pl. 71.

Dactylis spicis sparsis secundis scabris numerosis.

Gramen maritimum, spica crassa dactyloide terminali, odore rancido, culmo albo. Gron. Virg. 135.

β. Dactylis spicis alteriis secundis incisis erectis approximatis, calycibus unifloris subulatis. Gron. Virg. 134.

Habitat in Virginia, Canada, Lusitania.

Then follows a more extended description.

It is quite probable that Linnaeus may have included the two species that are now referred to *Spartina cynosuroides* Willd. and *S. polystachya* Willd. in the above, as he gives Canada as one of the type localities; while Merrill in his recent monograph of Spartina limits the range of the former from Canada to New Jersey and the latter from New Jersey to Florida. The two species were first distinguished by Michaux in his *Flora* as *Trachynotia cynosuroides* and *T. polystachya.* Michaux applied the specific names as have later authors under Spartina.

However, the specimen of *Dactylis cynosuroides* in the Linnaean Herbarium is *Spartina polystachya* Willd. (or Elliott, as Willdenow does not actually make the combination in his *Enumeratio*, but refers *Trachynotia polystachya* Michx. to Spartina). The specimen in the Gronovius Herbarium ("*Gramen maritimum*, etc.") is also *S. polystachya* Willd. Linnaeus's description might apply to either species, but better to S. *polystachya*, especially the statement "calycibus mucronatis," for in S. *cynosuroides* the second glume is short-awned.

The locality, Canada, may refer to the variety β, which is *Spartina glabra* Muhl. both as to the plant in Herbarium Linnaeus and Herbarium Gronovius.

The Rochester code would require that the specific name *cynosuroides* be applied to the Linnaean plant, but I will leave the transfer for those who are thus inclined. According to the Kew rule the names are correct as now used under Spartina.— A. S. HITCHCOCK, *U. S. Department of Agriculture, Washington, D. C.*

CURRENT LITERATURE.

BOOK REVIEWS.

Pathological plant anatomy.[1]

WITHIN the past few years several books on plant pathology have appeared, some of them being of great value. They have dealt almost exclusively, however, with but one side of the question, the cause and prevention of plant diseases, rather than with the phenomena shown by diseased plants themselves. The work now under consideration, as its title indicates, takes up an entirely different aspect of pathology, viz., the anatomy of pathological growths. Such conditions as are mere degenerations, like the decay caused by many fungi, are not discussed, but those progressive anatomical developments resulting from pathological conditions or causing them. This book differs from others in which pathological anatomy is discussed in that the pathological structures are classified, not according to the external causes supposed to produce them, nor according to their place of origin on the plant, but according to their actual structure as compared with one another.

The five descriptive chapters take up the following main subdivisions of the subject: *Restitution*, the process of replacing lost parts, is treated here, since the formation of the reparatory tissue, like the formation of many pathological tissues, is connected with a utilization of energy, which is spared the organism that develops normally. *Hypoplasy*, the incomplete development of cells or tissue, may affect only the size or other features of development, as for example the amount of differentiation. *Metaplasy*, by which is designated every progressive change of a cell that is not connected with its abnormal enlargement or division. *Hypertrophy*, used in the sense that Virchow used it, designates the production of abnormally large cells, which may be single or grouped to form an abnormal tissue or organ. It is to be distinguished from the subject of the following chapter, *hyperplasy*, which, again in Virchow's meaning, is the abnormal increase in size of tissues or organs caused by an abnormal multiplication of cells. The last two subjects are extensively discussed, the former having the following subdivisions: hypertrophy as a result of suppression of the division of the growing cell where normally division should occur; as a result of etiolation; hyperhydric growth, including the so-called "oedemata"; tyloses; gall hypertrophies, *e.g.*, galls due to Erineum and Synchytrium; and multinucleate giant cells, occurring mostly in hyperplastic growths and forming a transition to that subject. Hyperplasy exhibits itself in two general types; homoeoplasy, where the elements of the abnormal tissue are the same as those of the tissue from which it is derived, and heteroplasy, where the elements are in part or all different. The latter contains by far the greatest number of cases. Under it are grouped most calluses, wound cork, wound wood, and the vast majority of galls. The latter are very extensively discussed. Most of the galls caused by parasitic plants come under the heading of kataplasms, while the highly organized galls, of definite structure and form, mostly of insect origin, are discussed under the heading of protoplasms.

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[1] KÜSTER; ERNST, Pathologische Pflanzenatomie. pp. vii+312. *figs. 121.* Jena: Gustav Fischer. 1903. *M* 8.

The final chapter is devoted to theoretical considerations, and is in many respects the most interesting chapter in the book. Here are considered, so far as our knowledge will allow, the factors causing the various modifications of cells and tissues. The stimuli themselves are discussed, the reaction of cells and tissue to the stimuli, and finally the comparative sensitiveness of different tissues to the stimuli. This chapter, so far as it goes, is a valuable contribution to the study of the developmental mechanics of plants.

The illustrations are, as a whole, very good, as they illustrate clearly the structural features. They are, with few exceptions, line drawings, and a trifle over half are original. An extensive working bibliography is found in the footnote references.—ERNST A. BESSEY.

MINOR NOTICES.

STRASBURGER'S[2] *Das botanische Practicum* has reached the fourth edition. It seems safe to say that no botanical text-book of modern times is more fully abreast of the present state of knowledge. While the new edition preserves the general arrangement and sequence of subjects which have proved satisfactory in previous editions, each subject has been carefully revised and brought up to date, even matters like the latest investigations upon protoplasmic connections receiving attention. The newest methods in technique are also presented.

The indices are more extensive than in any previous edition, occupying 145 pages. There are five, as follows: I. An alphabetical index of the plants which are used as illustrative material. II. A list of plants used as illustrative material, arranged with reference to the time of year at which they should be collected. III. A list of stains and reagents. IV. Reagents, stains, plant substances, imbedding media, and sealing media; chemical exercises; instruments, apparatus, and their use; making of preparations; and physical exercises. V. General index. The first two indices will be suggestive and helpful to those who have the responsibility of keeping laboratories supplied with illustrative material. The fourth index is so full that in very many cases it will hardly be necessary for the well-informed teacher to look up the reference in the body of the book. This book is not to be confused with the *Handbook of Practical Botany* "by Dr. E. Strasburger," which is the fifth English edition of a translation by Hillhouse of an earlier edition of *Das kleine botanische Practicum*. Some of the defects of this English edition, which bears Professor Strasburger's name, although it does not represent his views, were noted in the April (1902) number of the GAZETTE.—CHARLES J. CHAMBERLAIN.

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[2] STRASBURGER, EDUARD, Das botanische Practicum. Fourth edition. 8vo. pp. l + 771. *figs. 230.* Jena: Gustav Fischer. 1902. *M* 20.

THE LAST two parts of Wiesner's[3] *Die Rohstoffe des Pflanzenreiches* have just appeared from the press of Wilhelm Engelmann. This completes the second volume and the work, and is accompanied by title-pages and index. Unhappily the latter is in two parts, one containing the names of crude materials and the other the systematic names of the plants from which they are derived. The two should have been combined, so as to make only one place to look for any item. But a thorough index is such a boon, and one so often denied us by German authors, that we readily condone a superfluity. The present double *Lieferung* contains the conclusion of the twenty-third section on *fruits* (pp. 801–871), and, far out of its place, the rest of the seventh section on *woods* (pp. 872–1027) by Professor Dr. Karl Wilhelm. In this part a description is given of the woods of deciduous trees, both as to their general and microscopic characters, with remarks on the uses to which the wood is put. Over one hundred kinds are described, some including several species. Of ten or a dozen the botanical derivation is not known.—C. R. B.

THE FIRST number of *Annales Mycologici* under the editorship of H. Sydow, announced in the BOTANICAL GAZETTE for December, has appeared. It contains 96 pages, and the following list of contributors gives promise of a very strong journal: P. Dietel, H. and P. Sydow, P. A. Saccardo, A. von Jaczewski, C. Wehmer, F. Cavara, L. Matruchot, P. A. Dangeard, and J. Bresadola. It should be suggested to the editor that a table of contents would make the journal much more convenient for consultation.—J. M. C.

NOTES FOR STUDENTS.

MOLISCH finds[4] that the red color produced in the leaves of a number of species of Aloe when brought into open sunlight from the greenhouse is not due to anthocyan but to the red coloration of the chloroplasts themselves.

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[3] WIESNER, JULIUS, Die Rohstoffe des Pflanzenreiches. Versuch technischer Rohstofflehre des Pflanzenreiches. Zweite gänzlich umgearbeitete und erweiterte Auflage. 11 und 12 Lieferung. 8vo. pp. 801–1071. *figs. 249–297*. Index to both volumes. Leipzig: Wilhelm Engelmann. 1903. *M* 10. (Two vols. unbound, *M* 60; bound *M* 66.)

[4] MOLISCH, H., Ueber vorübergehende Rothfärbungen der Chlorophyllkörner in Laubblättern. Ber. Deutsch. Bot. Gesells. **20**: 442–448. 1902.

He finds red or red-brown chromoplasts also in seven species of Selaginella. The pigment proves to be a carotin.—C. R. B.

Centrosome-like bodies in the vegetative cells of the vascular cryptogams have been reinvestigated by Professor Němec.[5] The principal material was root-tips of *Blechnum braziliense*, *Diplazium pubescens*, *Dracaena arborea*, *Hibiscus calycinus*, and *Alnus glutinosa*. It was not difficult to find bodies which resembled centrosomes and would doubtless be interpreted as such by those who expect to find centrosomes in every cell. The writer comes to the conclusion, however, that there are no genuine centrosomes in the vegetative cells of the vascular plants, and unless blepharoplasts are centrosomes — and he believes they are not — that there are no centrosomes at all in vascular plants. The figures look like those which are familiar to any one who has made preparations of mitotic figures in root tips. Professor Němec states that with the same technique which he used for the root tips he was able to differentiate clearly the centrosomes of the liverworts.—Charles J. Chamberlain.

One may get a very clear statement of Dangeard's[6] views on sexuality and related phenomena from a paper by him in *Le Botaniste*. Dangeard believes that the sexual act had its beginning through starved zoospores which fused with one another to satisfy this hunger. Sexuality was thus primarily autophagy. Parthenogenesis is to be expected whenever gametes find an environment sufficiently favorable for the vegetative activities common to all spores, *i. e.*, when taken out of their famished condition. These first principles form the basis of a discussion of reduction phenomena, the evolution and differentiation of sexual cells, a comparison of sexual processes in animals and plants, and other topics.

This is an interesting paper, presented in an attractive style. One must be cautious, however, in following Dangeard, for he deals with the most difficult field of speculative biology, where conditions are undoubtedly far more complex than is generally believed.—B. M. Davis.

Ruhland[7] has made a preliminary report on the fertilization of some species of Peronospora and Sclerospora, and especially *Albugo Lepigoni*. The conditions in the latter are especially worth noting, since it adds a fifth form in Stevens's interesting series of four species in this genus (*Albugo Bliti*, *A. Portulacae*, *A. Tragopogonis*, and *A. candida*). *Albugo Lepigoni* has a very large coenocentrum and a much reduced receptive papilla, so that it stands at the *candida* end of the series. As a rule only one nucleus enters the ooplasm, taking its position near the coenocentrum, where it divides with a smaller nuclear figure than the previous mitoses in the oogonium. The evidence is not sufficient to justify the speculation that this is a reduction division. One of the daughter nuclei degenerates, the other becomes the female gamete nucleus and lies close to the coenocentrum, where it fuses with the male nucleus. The attraction of the coenocentrum for the gamete nuclei and its nourishing relations are especially evident.—B. M. Davis.

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[5] Němec, B., Ueber centrosomähnliche Gebilde in vegetativen Zellen der Gefässpflanzen. Ber. Deutsch. Bot. Gesell. **19**: 301–310. *pl. 15*. 1901.

[6] Dangeard, P. A., Théorie de la sexualité. Le Botaniste **6**: 263–290. 1898.

[7] Ruhland, W. von, Die Befruchtung von *Albugo Lepigoni* und einigen Peronosporeen. Hedwigia **41**: 179–180. 1902.

Czapek found in 1897[8] that a substance was present in geotropically stimulated roots which had a strong reducing action upon silver nitrate, and that in an unstimulated root there was less of it. He has now determined[9] that this substance is homogentisic acid, an oxidation product of tyrosin. The increase of homogentisin amounts at the maximum to 15 per cent., which is reached about the time the curvature begins to appear, from which time it falls off. (A similar phenomenon also occurs in phototropic organs on stimulation.) The zone in which it is found extends above the receptive zone to that of maximum growth. Czapek holds that his finding an increase of homogentisin in horizontally placed roots from which the terminal millimeter had been cut away excludes the strict form of Němec's hypothesis, that the starch-bearing cells of the root-cap *alone* constitute the perceptive organs for the geotropic stimulus. The accumulation of homogentisin in stimulated roots seems to be due to the temporary retardation of oxidative processes by special substances, soluble in water, insoluble in alcohol, and destroyed by heat. These Czapek suggests may be anti-enzymes, *e. g.* (anti-oxydase).—C. R. B.

Items of taxonomic interest are as follows: F. Stephani (Bull. Herb. Boiss. II. 3: 98–129. 1903), in continuation of his *Species Hepaticarum*, has described 20 new species of Plagiochila from tropical Asia and Oceanica, and 82 from the antarctic regions.—C. Mez (*idem* 130–146) has described 22 new species of Bromeliaceae.—A. S. Hitchcock (Bureau Plant Industry, Bull. 33) has published a revision of the North American species of Leptochloa, recognizing 15 species and excluding *L. Brandegei* Vasey.—F. S. Collins (Rhodora 5: 1–31. *pls. 41–43.* 1903) has published a revision of North American Ulvaceae, recognizing 3 species in Ulva, 10 in Monostroma, 19 in Enteromorpha, and 1 in Ilea.—J. C. Arthur and E. W. D. Holway (Bull. Lab. Nat. Hist. State Univ. Iowa 5: 311–334. *pls. 1–9.* 1902) in their fourth paper describing American Uredineae deal with the rusts inhabiting species of Agrostideae and Chlorideae, including 16 species, one of which is new.—W. A. Murrill (Torreya 3: 7. 1903) has established a new family (*Xylophagaceae*) of the Basidiomycetes, based on *Xylophagus* Link and allied genera formerly included in Polyporaceae.—T. D. A. Cockerell (*idem* 7–8) has described a new oak (*Q. Rydbergiana*) from New Mexico.—A. W. Evans

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[8] Czapek, F., Ueber einen Befund an geotropisch gereizten Wurzeln. Ber. Deutsch. Bot. Gesells. 15: 516. 1897.

[9] *Idem* 20: 464. 1902.

(Bull. Torr. Bot. Club **30**: 19–41. *pls 1–6.* 1903), in continuation of his "Hepaticae of Puerto Rico," has presented the genus Drepanolejeunea, including 10 species, and described 4 of them as new.—L. M. UNDERWOOD (*idem* 42–55), in publishing an index to the described species of Botrychium, has added 6 new species to the genus.—J. M. C.

THE REPRODUCTION of the interesting fungus Dipodascus, considered by some as one of the Hemiasci, is described by Juel[10] as follows: The sexual cells are multinucleate, the sexual nuclei being indistinguishable from the vegetative. After their union there is present a larger nucleus supposed to result from the fusion of two gamete nuclei. This fusion nucleus lies in the spore sac and gives rise to a large number of products which are much larger than the vegetative nuclei. The former become the centers of free spore formation and the latter remain with surplus cytoplasm in the sac. Juel regards Dipodascus as intermediate between the Phycomycetes and Ascomycetes. The spore sac is not homologous with an ascus but corresponds to a cell complex and consequently the form takes a low position in the series of Ascomycetes, near to but somewhat higher than Eremascus. There are lacking in Juel's investigation important stages in the nuclear history at the time of fertilization and during spore formation. These gaps make one hesitate to follow him in his views, and we are justified in asking for details on these points. It is not altogether clear that Dipodascus is an ascomycete. Perhaps it may be on a line by itself, with relationships somewhere among the molds. The sexual cells seem very close to coenogametes in spite of the fact that each is said to contain only one sexual nucleus, and spore formation in the sac, from Juel's account, does not seem like that in the typical ascus. Indeed, the spore sac suggests a germinating zygospore, perhaps exhibiting sporophytic tendencies which lead it to develop at once into a sporangium-like structure. These are some of the queries that present themselves.—B. M. DAVIS.

THE PHYLOGENY of the cormophytes, as indicated by their sporophylls and foliage leaves, is discussed in a long paper by Hallier.[11] The immense amount of detail and comparative morphology, especially in discussing the sporophyll, cannot be considered here, but a few of the conclusions and the principal features of the scheme of phylogeny may be of interest. Funiculus and integument correspond to a leaf pinna, on the upper side of which the megasporangium (nucellus) develops. The sporophyll of an angiosperm corresponds in general to the simple pinnate sporophyll of Cycas. In the Coniferales one, two, or more ovular pinnae are present, united congenitally by their edges. The staminate sporophylls of gymnosperms and angiosperms are composed of two (seldom more) fertile pinnae and a sterile middle lobe, the latter being frequently suppressed. The typical staminate sporophyll of the angiosperms has come from the wedge-shaped or band-shaped sporophyll of the gymnosperms, Anonaceae, Magnoliaceae, Nymphaeaceae, etc. The sporophyte generation of the archegoniates is equivalent to the gametophyte generation, and has arisen from the gametophyte generation through the reduction of the sex organs. The archegoniates came from liverworts or algae, in which the two generations were equal in vegetative work and in which both generations had the dichotomous thallus. From this condition the sporophyte in the ferns advanced in its development, while in the mosses it degenerated and became dependent. All the Strobiliferae (cone-bearing pteridophytes and gymnosperms) have come from tree ferns of marattiaceous ancestry. The Gnetaceae are related to the Loranthaceae and Santalaceae; Ephedra, however, may be related to Casuarina and Myrothamnus. The Bennettitales are an extinct connecting link between the Cycadales and the Magnoliaceae. From the Magnoliaceae, directly or indirectly, come the rest of the dicotyledons, and also the monocotyledons, the latter coming from the region of the Ceratophyllaceae and Ranunculaceae.—CHARLES J. CHAMBERLAIN.

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[10] JUEL, H. O., Ueber Zellinhalt, Befruchtung und Sporenbildung bei Dipodascus. Flora **91**: 47–55. *pls. 7–8.* 1902.

[11] HALLIER, H., Beiträge zur Morphogenie der Sporophylle und des Trophophylls in Beziehung zur Phylogenie der Kormophyten. Jahrb. Hamburgischen Wiss. Anstalten **19**: 1–110. 1902.

THE INFLUENCE of the nucleus upon the growth of the cell is described in a recent paper by Gerassimow.[12] The work is strongly supported by forty-seven tables which record the quantitative relations. Spirogyra was the plant used, and the conclusions depend upon a comparison of the behavior of nucleated and non-nucleated cells. Non-nucleated cells were obtained by disturbing the mitosis so as to move the nucleus from its central position toward one side; on the completion of the partition, one of the cells (in successful cases) would be left without a nucleus, although its chromatophores and other structures seem to be normal. As is known, Spirogyra divides late in the evening or at night, but division may be delayed until morning by lowering the temperature, the division taking place when the temperature is allowed to rise. The writer preferred to use material found dividing spontaneously. Such material was placed in a suitable vessel, surrounded by snow or crushed ice, and kept near the freezing point for about an hour, but was not allowed to freeze. It was then brought gradually to the room temperature. On the following morning many non-nucleate cells and chambers would be found. Although division may be induced by ether, this method was very little used. The following are some of the conclusions: The growth of a cell which has a superabundance of nuclear material is more vigorous than that of the ordinary uninucleate cell. The cell wall, the chromatophores, and apparently the protoplasm also grow more vigorously. Such cells divide only after they have reached a noticeably larger size. Non-nucleate cells can grow somewhat in length. The non-nucleate chamber (which is distinguished from the non-nucleate cell by a larger or smaller opening in the partition separating it from its sister cell with the superabundance of nuclear material) grows more vigorously than the non-nucleate cell. Cells with a superabundance of nuclear material can conjugate with each other or with ordinary cells, and the size of the zygospore is in direct relation to the size of the conjugating cells.—CHARLES J. CHAMBERLAIN.

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[12] GERASSIMOW, J. J., Ueber den Einfluss des Kerns auf das Wachsthum der Zelle. Bull. Soc. Imp. Nat. Moscow **1901**: 185–220. 47 tables and *2 pls.*

THE CONCLUSION of a paper by Matruchot and Molliard on the changes produced by freezing in the structure of plant cells, enables us to present a summary of their conclusions.[13]

The freezing of tissues always creates a demand for water at the exterior of the cell which produces a general and rapid outgo both of the water of the cell sap and the water of imbibition held by the protoplasm, resulting in a vacuolization of the latter, by which the cytoplasm becomes alveolar, and the nucleus a network of thick filaments and large meshes. The water once extracted from the plasma makes its way into the sap cavity either by simple osmosis, as is generally the case for the nucleus and probably for the cytoplasm, or by the bursting of the vacuoles and the escape of their contents outward, as in certain nuclei.

Exosmose of the water from the cytoplasm does not produce any easily observed structural modification. In the nucleus, however, the currents produced by the rapid exit of water in response to the demand from without, determino a uni-, bi-, or multipolar orientation of the nucleoplasmic framework, according as there are one or more directions of easy exit from the water. The "poles" are more watery and consequently less chromatic than the rest of the nucleus. They are always related in position to the sap cavity; the thinner the layer of protoplasm which separates the nucleus from the sap cavity the easier the exit and the more distinct the "pole." When very thin the wall of the nucleus may even be ruptured, letting the water escape bodily into the sap cavity.

The same alterations of structure as are produced in cytoplasm and nucleus by freezing can be produced by depriving them of water by other means, *e. g.*, by plasmolysis and by natural or artificial drying. The cytological evidence thus confirms Molisch's theory that death by freezing is in reality death by desiccation.

It will be evident at once that this paper has an important bearing upon certain cytological problems, since our modes of killing and fixing involve the relatively violent withdrawal of water, which the authors declare determines the orientation of nuclear material.—C. R. B.

SHIBATA[14] in an interesting preliminary paper records his experiments upon the structures of the embryo sac of *Monotropa uniflora*. Most of the observations were made upon material in the living condition. The interval between pollination and fertilization is dependent upon temperature. Under normal conditions fertilization takes place about five days after pollination, and on the same day or the next day from two to four cells are found in the endosperm. The fertilized egg elongates and bores its way into the nearest endosperm cell. Seeds ripen in about fifteen days after pollination, Light, atmospheric pressure, and mechanical injury of the ovule or other parts of the plant seem to exert no influence upon fertilization and subsequent phenomena, but the structures of the embryo sac are very sensitive to temperature. At 28° C. fertilization and subsequent phenomena proceed as at room temperature, and at 30° C. the endosperm nucleus can still divide; but at 31–32° C. fertilization can no longer take place, and disturbances are seen, due probably to increased osmotic pressure of the sac. By lowering the temperature the interval between pollination is lengthened, and at 8–10° C. fertilization is prevented. The experiments show that the polar nuclei may fuse in the absence of pollination, but that the fusion may be hastened or regulated by pollination; in normal cases the fusion occurs about five days after pollination, but when pollination is prevented, the interval may be prolonged to ten days or even longer. The three small antipodal cells disintegrate after fertilization, but when fertilization is prevented artificially, they may enlarge enormously and fill a considerable portion of the sac. At a temperature of 30° C. or higher there is no growth of the antipodals. Development of the endosperm can be induced experimentally in the absence of fertilization. When pollination is prevented, many of the ovules die within two or three weeks, but in others the sac enlarges and becomes filled with endosperm. In such cases the egg apparatus and often the antipodals collapse. This development of the endosperm was observed in 3 to 5 per cent. of the ovules, but at a temperature of 28° C., or by using osmotic solutions, endosperm was developed by 6 to 12 per cent. of the seeds. The writer believes that the endosperm nucleus has a stronger tendency toward parthenogenetic development than the egg. The full paper with plates will be awaited with interest.—C. J. CHAMBERLAIN.

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[13] MATRUCHOT, L. and MOLLIARD, M., Modifications produites par le gel dans la structure des cellules végétales. Revue Gén. Bot. **14**: 401, 403, 522. 1902.

[14] SHIBATA, K., Experimentelle Studien über die Entwickelung des Endosperms bei Monotropa. (Vorläufige Mitteilung.) Biol. Centralbl. **22**: 705–714. 1902.

IN THE January number of the *Revue Général de Botanique*, M. Luigi Macchiati announces his complete confirmation of the observation of Friedel (1901) that photosynthesis occurs *in vitro*, without the intervention of living protoplasm, by the action of an enzyme which utilizes the solar energy in the presence of chlorophyll. Several physiologists, including Macchiati and Friedel himself, repeated Friedel's earlier experiments with negative results. Now, however, Macchiati has obtained positive evidence, which he outlines, pending the publication of a more extended paper. Briefly his process and results are these:

Carefully washed leaves are extracted with equal parts of sterile distilled water and *c. p.* glycerin. The extract may be used or the enzyme obtained separately by shaking the extract with benzene, which is then decanted, carrying with it the enzyme, which settles as a flocculent amorphous precipitate. Other leaves, carefully washed, are dried at 100° C., powdered in a sterile glass mortar, and preserved in sterile glass with ground stopper. From the powder also the enzyme may be extracted, as it bears a heat of 100° for some time. Repeated extraction, washing, and drying frees it from the enzyme completely. The liquids to be tested were put into a beaker, in which is plunged an inverted funnel, having inverted over its stem a graduated test tube filled with liquid, into which the gases rise as they are set free.

Repeated experiments show that the glycerin extract from the living leaves or from the powder is unable alone to accomplish photosynthesis in light. On the contrary, the powder alone, if it contain the enzyme, when put into distilled water always causes an evolution of oxygen, and at the same time produces formaldehyde, the presence of the latter being demonstrable by the codein test. The enzyme is only able to produce photosynthesis in light if chlorophyll be present, which, as Friedel thought, seems to act as a sensitizer. The addition of an antiseptic, *e. g.*, $HgCl_2$ 1 : 2000, does not interfere with the process. CO_2 is absorbed from the air by the liquid in the beaker. The evolution of O is always proportional to the illumination. The leaves do not always yield the enzyme; they must be collected at a proper season.

These results seem not only to demand a new point of view regarding the nature of photosynthesis, but to furnish a new and strong support to Baeyer's hypothesis as to the process. At present the condensation of formaldehyde into a complex carbohydrate is not accounted for, nor do we know how a chemical sensitizer acts.—C. R. B.

THE PATH BROKEN by Jacobi (Flora **86** : 289–327. 1899) has been explored much farther by Treboux,[15] who agrees that even dilute doses of the stronger metallic poisons hinder photosynthesis in Elodea. Anesthetics and alkaloids act in the same way. Milder poisons such as KNO_3 exercise no very considerable influence until concentrated enough to plasmolyze the cell, when they permanently injure it. Acids, including carbonic acid, accelerate the evolution of oxygen in proportion to their concentration (within limits, of course). No evidence could be found for the formation of starch from formaldehyde, nor for any place for formaldehyde in photosynthesis. The Elodea used for these experiments, conducted in Leipzig, seems to have been a great deal more sensitive than the Chicago material (cf. the February number of the GAZETTE, p. 96).—E. B. COPELAND.

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[15] TREBOUX, O., Einige stoffliche Einflüsse auf die Kohlensäureassimilation bei submersen Pflanzen. Flora **92** : 49–76. 1903.

A STUDY OF THE VEGETATION which has appeared upon Krakatoa since the destructive eruption of 1883 was made by Penzig[16] in 1897. The plants and their distribution he found in harmony with what could be expected from the report of the study made by Treub in 1886. The beach flora is the characteristic Pes-Caprae-formation of tropical islands, about twelve species composing it here. Beyond the beach, covering the lava hillocks and valleys, very tall grasses (*Gymnothrix elegans*, *Saccharum spontaneum*, and *Phragmites Roxburghii*) intermixed with vines (*Scaevola Koenigii*, *Ipomœa*, *Vigna*, etc.) predominate. Shrubs and other species are but isolated, so the vegetation may well be distinguished as a savanna. Above this, on the cliffs, ferns grow abundantly; while upon the more exposed rocks Cyanophyceae do the work performed in higher latitudes by lichens. In all 62 species (50 seed-plants and 12 vascular cryptogams) were found, as compared with 15 seed-plants and 11 ferns over ten years earlier. No mangrove trees grow about Krakatoa, nor as yet forest trees upon it. As to the means by which the island was seeded, it was learned that 60.39 per cent of the plants owe their arrival to ocean currents, 32.07 per cent. to the wind, and 7.57 per cent. to animals.— ETOILE B. SIMONS.

THE LIFE HISTORY of *Ruppia rostellata* is described in a recent paper by Murbeck.[17] It is suggested that pollination may take place under water as well as at the surface, although definite proof was not obtained. During the development of the microspores the tapetal cells break down, and their nuclei float free in the liquid which fills the cavity of the microsporangium. The formation of two definite male cells within the irregularly elongated pollen grain was traced in detail. A tapetal cell is formed, and the megaspore mother cell gives rise to four megaspores which are not arranged in a row, but the two lower spores lie one above the other while the two upper ones lie side by side or somewhat obliquely. This arrangement was observed in numerous instances. In one peculiar case the archesporial cell seems to have divided obliquely instead of by a pericline, and both resulting cells show the distinguishing characters of megaspore mother cells. In this mitosis, by which the archesporial cell gives rise to the tapetal cell and megaspore mother cell, the number of chromosomes was found to be sixteen. This number was also counted in other sporophytic cells. In the first division of the megaspore mother cell and also in the microspore mother cell the number is eight. The polar nuclei fuse completely before fertilization. Although the pollen tubes were traced to the embryo-sac, the actual process of fertilization was not observed. At the first division of the endosperm nucleus a wall is formed, dividing the sac into two chambers. The chamber at the antipodal end is small and its nucleus does not divide, but in the other chamber a large number of free nuclei are formed. A study of the embryo confirms the account of Wille that a primary root is formed at the base of the embryo, but soon disorganizes, and a lateral root, which is formed very early, is the first functional one. This is very different from the account of Ascherson in Engler and Prantl's *Die natürlichen Pflanzenfamilien*, and followed in Goebel's *Organography*, according to which this lateral root is the primary root, its unusual position being due to displacement.—CHARLES J. CHAMBERLAIN.

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[16] PENZIG, O., Die Fortschritte der Flora des Krakatau. Ann. Jard. Bot. Buitenzorg **18**: 92–113. 1902.

[17] MURBECK, SV., Ueber die Embryologie von *Ruppia rostellata* Koch. Kongl. Svensk. Vetensk. Akad. Handl. **36**: 1–21. *pls. 1–3.* 1902.

MISS SARGANT[18] has proposed a theory of the origin of monocotyledons based on her studies of seedlings of Liliaceae. The single cotyledon is regarded as being derived from two cotyledons by fusion. Among the large number of genera described, Anemarrhena is regarded as showing a primitive structure in the vascular strands of its seedling. The cotyledon of this plant shows two bundles with the xylem groups facing each other. This seedling is compared with that of the ranunculaceous genus Eranthis, in which the petioles of the two cotyledons are fused, forming a tube which contains two bundles; and the similarity is considered to be the result of inheritance from a common ancestor. Other genera of Liliaceae are described, forming series of increasing complexity, and the conclusion is reached that there is no true midrib in the cotyledons of this family. A consideration of other moncotyledonous seedlings follows, and the nature of the "monocotyledonous dicotyledons" is discussed, special reference being made to *Ranunculus Ficaria*, the single cotyledon of which is regarded as a fusion of two. Lists of dicotyledons with tubular cotyledons are given, and from the fact that practically all of these are geophilous plants she infers that the fused condition of the cotyledons in the monocotyledons has arisen in connection with the geophilous habit. — M. A. CHRYSLER.

TWO VERY interesting lichen-like associations of fungi with marine algae have been described by Minnie Reed.[19] She speaks of them as an Ulva-composite and a Prasiola-composite from the two algae concerned. The fungus in both instances is an ascomycete of the genus Guignardia, but the species are different.

Guignardia Ulvae n. sp. is associated with *ulva californica*, and the composite grows at "upper tide mark on the shady side of sandstone bowlders," at the entrance of the Bay of San Francisco. The Ulva-composite occurs in large and small patches, sometimes mixed with Ulva and Enteromorpha, and has been found at all seasons of the year with perithecia. The form of the plant suggests *Enteromorpha Linza*. Sections are striking because of the very large amount of the fungus. The algal cells are distributed singly or in groups, contained in capsules formed by a network of hyphae and in a gelatinous matrix. There is a central zone of mycelium so thick that the two layers of algal cells are widely separated. The perithecia are blackish swellings on the surface of the thallus, the cavity is lined with a pseudoparenchymatous layer from which the asci arise and there is a well-developed ostiole, lined with hairs that project outward. The ascospores are discharged in great numbers and germinate readily. It is probable that the germ tubes enter the Ulva sporeling at very early stages of development, and that they do not attack mature plants, for the latter have never been found partially infected. So the alga and fungus seem to develop together almost from the germination of the respective spores.

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[18] SARGANT, ETHEL, A theory of the origin of monocotyledons, founded on the structure of their seedlings. Annals of Botany **17**: 1–92. *pls. 1–7.* 1903.

[19] REED, MINNIE, Two new ascomycetous fungi parasitic on marine algae. Univ. Calif. Pub. Bot. **1**: 141–164. *pls. 15, 16.* 1902.

The Prasiola-composite came from Alaska. The fungus *Guignardia alaskana* n. sp. changes the character of the Prasiola plant (which is a new species, named *Prasiola borealis*), coloring it darker, and giving it a curled crinkled, and leathery texture in old plants. The monostromatic fronds become from 8-16 layers of cells thick after infection, and the algal cells are scattered very irregularly in the mass of mycelium. Another Prasiola-composite has been known for some years from the Antarctic, first described by Hooker (1845) under the name of *Mastodia tessellata*, its true nature being discovered by Hariot in 1882. The relation of the fungus to its algal host in these three composites is apparently essentially the same as in the lichens. The fungus must depend upon the alga for its organic material, and consequently operates as a parasite. Whether the alga gets any benefit from the association is very problematical. It is possible that the tougher texture of the frond may better resist wind and wave, but marine algae are generally well able to care for themselves in these respects and non-infected material grows successfully side by side with the composite plants.

It seems plain that these composite organisms are lichens, certainly as much so as is Ephebe, and we wonder if the author has special reasons for avoiding that name, and whether she thinks it should be replaced by a term indicating the dual nature of these plants.—B. M. DAVIS.

NEWS.

Mr. C. G. Pringle is making a collection of Cuban plants in the vicinity of Cienfuegos.

Dr. J. H. Barnhart has been elected editor-in-chief of the publications of the Torrey Botanical Club.

The German Botanical Society has elected Professor Schwendener president, and Professor Wettstein vice-president.

Professor L. M. Underwood has gone to the West Indies to spend six months in the study of tropical American ferns.

Professor Bruce Fink, of Upper Iowa University, has accepted the new chair of botany at Iowa College, Grinnell, Iowa.

Professors Solms-Laubach and Goebel have been elected honorary members of the Zoological-Botanical Society of Vienna.

Jordan's *Icones Florae Europae,* of which only 100 copies were printed, will be completed this year by the publication of the lacking 220 plates.

The Sharon Biological Observatory, a summer school for teachers at Sharon, Mass., will experiment in forestry on a tract of 300 acres of woodland, which it purposes making into a model forest.

The Desmazières prize of the Paris Academy of Sciences has been awarded to Professor Roland Thaxter, of Harvard University, for his study on the parasitic fungi of American insects.—*Science.*

The task of growing valuable forests on the barren sand-hills of Nebraska will begin this spring, when the Bureau of Forestry will seed about 100 acres of Dismal River Forest Reserve near Halsey with red cedar and jack pine.

Joseph Burtt Davy, instructor in botany in the University of California, has accepted the position of state agrostologist and botanist to the Department of Agriculture of the Transvaal government, with headquarters in Pretoria.—*Science.*

We are informed that the large private botanical library of the late Alexis Jordan, of Lyon (1814–1897), containing many valuable works on the flora of Europe, will be sold by auction next May. Paul Klincksieck, 3 rue Corneille, Paris, is preparing the catalogue and will send it free on application as soon as ready.

The Connecticut Botanical Society was organized in New Haven, January 24, 1903, and the following officers elected: Professor Alexander W.

Evans, president; Dr. C. B. Graves, vice-president; Dr. E. H. Eames, recording secretary and treasurer; and Mr. E. B., Harger, Oxford, Conn., corresponding secretary. Thirty-one persons were present. Papers were read by Mr. E. B. Harger, and Mr. W. E. Britton, and a graphic account of "The geographic distribution of certain New England plants," was presented by Mr. M. L. Fernald. In conformity with a plan to collect material for a complete catalogue of the flora of the state, a committee on the higher plants, including the pteridophytes, was appointed, viz., Dr. C. B. Graves, New London; E. H. Eames, Bridgeport; Mr. C. H. Bissell, Southington; Mr. L. Andrew, Southington; Mr. E. B. Harger, Oxford; and Mr. J. N. Bishop, Plainville. Field meetings are to be held in some of the least known portions of the state, the flora of Northeastern Connecticut, for example, being almost wholly unrecorded.—E. H. EAMES.

FROM ADVANCE sheets of the *Report* of the Missouri Botanical Garden for 1902 we gather the following information: A series of plant houses of modern design and good construction were erected at a cost of $7,000. During the year, 128 species or varieties of plants were dropped from cultivation, and 1,712 were added, making a net gain of 1,584 for the year. The total number recorded as cultivated is now 11,551. Over two thousand plants were distributed to hospitals and schools, and 392 plants, cuttings, or packets of seeds were sent to correspondents of the Garden. In exchange for the latter material and the publications of the Garden, or as gifts, 11,613 plants and packets of seeds were received. The number of visitors in 1902 was 21,052 greater than in the highest previous year (1901) for which records have been kept, reaching a total of 112,314. The herbarium has been increased by the acquisition of the herbarium of Professor G. C. Broadhead, valuable as verifying the occurrence in Missouri of plants referred to in the early geological reports on the state, and by the incorporation of 62,844 sheets of specimens, of which 15,551 were presented or received in exchange for material or publications, 469 were collected by employees of the Garden, and 47,224 were bought. The herbarium, so far as now mounted, contains 427,797 specimens. The library has been increased by the addition of 1,524 books and 697 pamphlets, purchased, and 992 books and 1,995 pamphlets, presented or received by way of exchange. Among the notable additions to the library should be mentioned an extensive collection of books published before the time of Linnaeus, and therefore complementary to the pre-Linnaean library presented by Dr. Sturtevant in 1892. As now constituted, the library contains 22,608 pamphlets, 18,550 books, and 302,955 index cards. The current list of serial publications received includes 1,160 titles.

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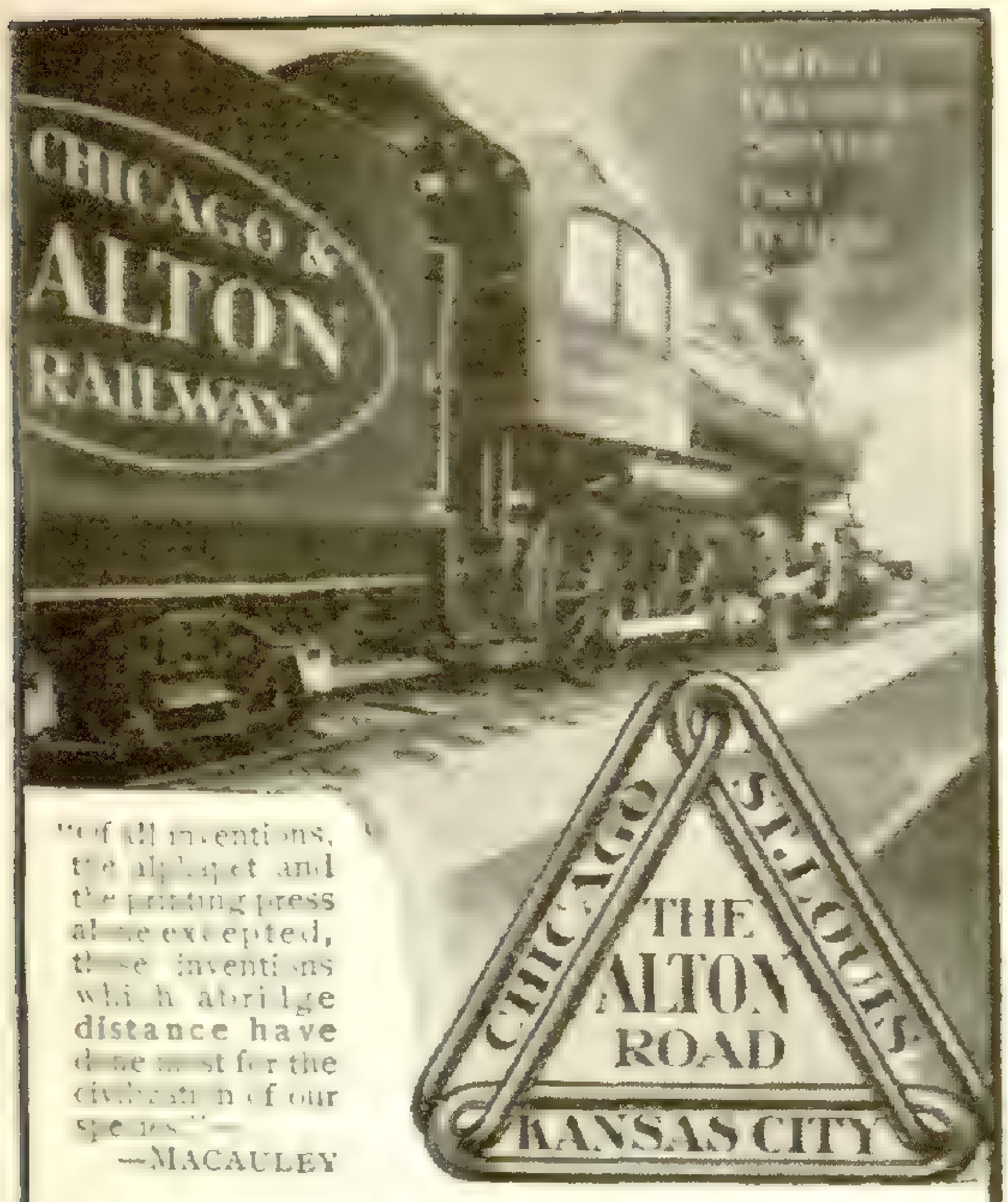

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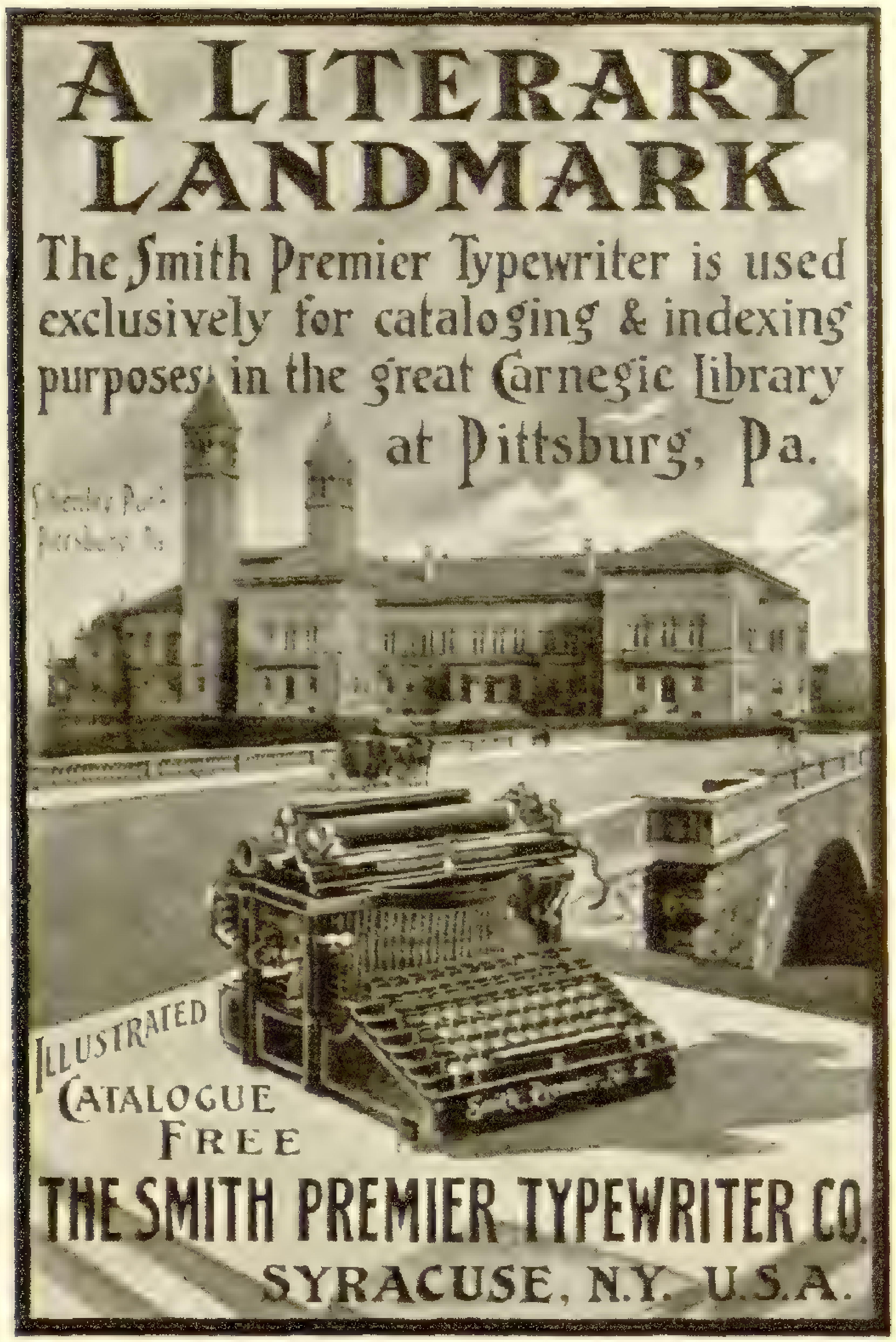

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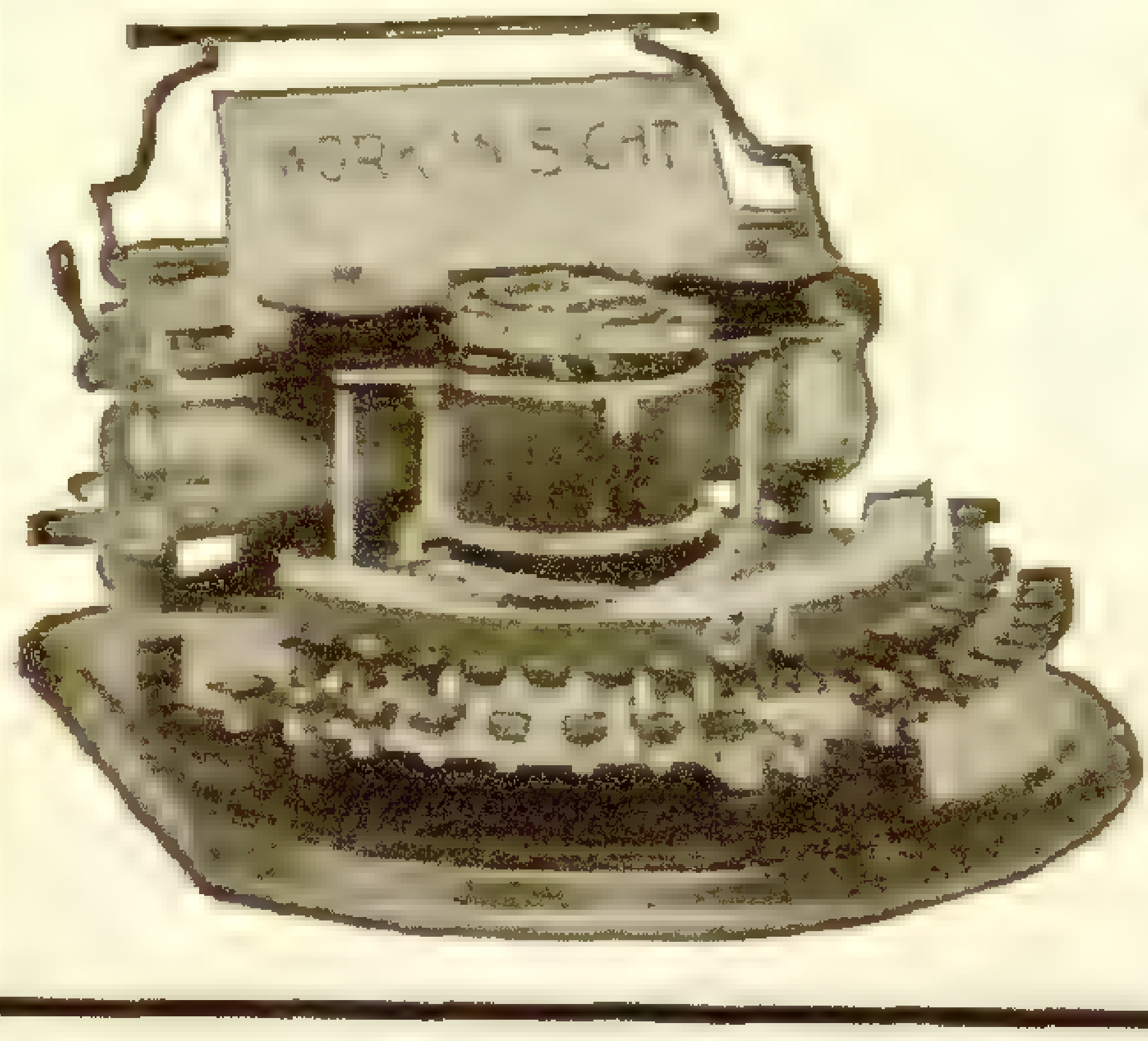

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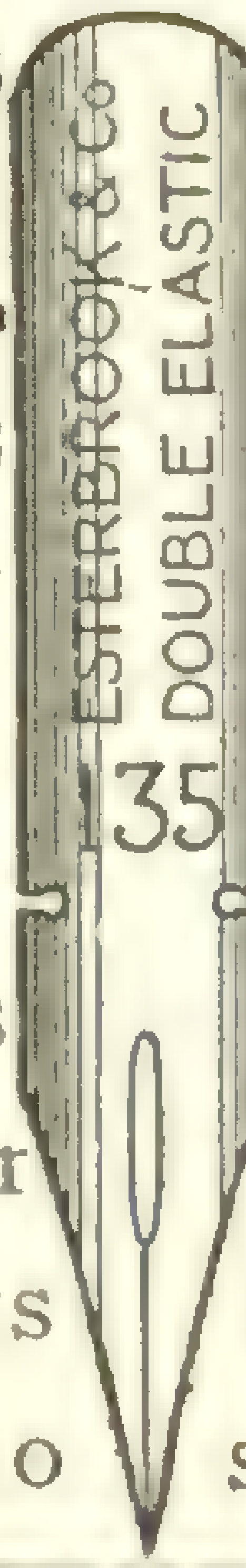

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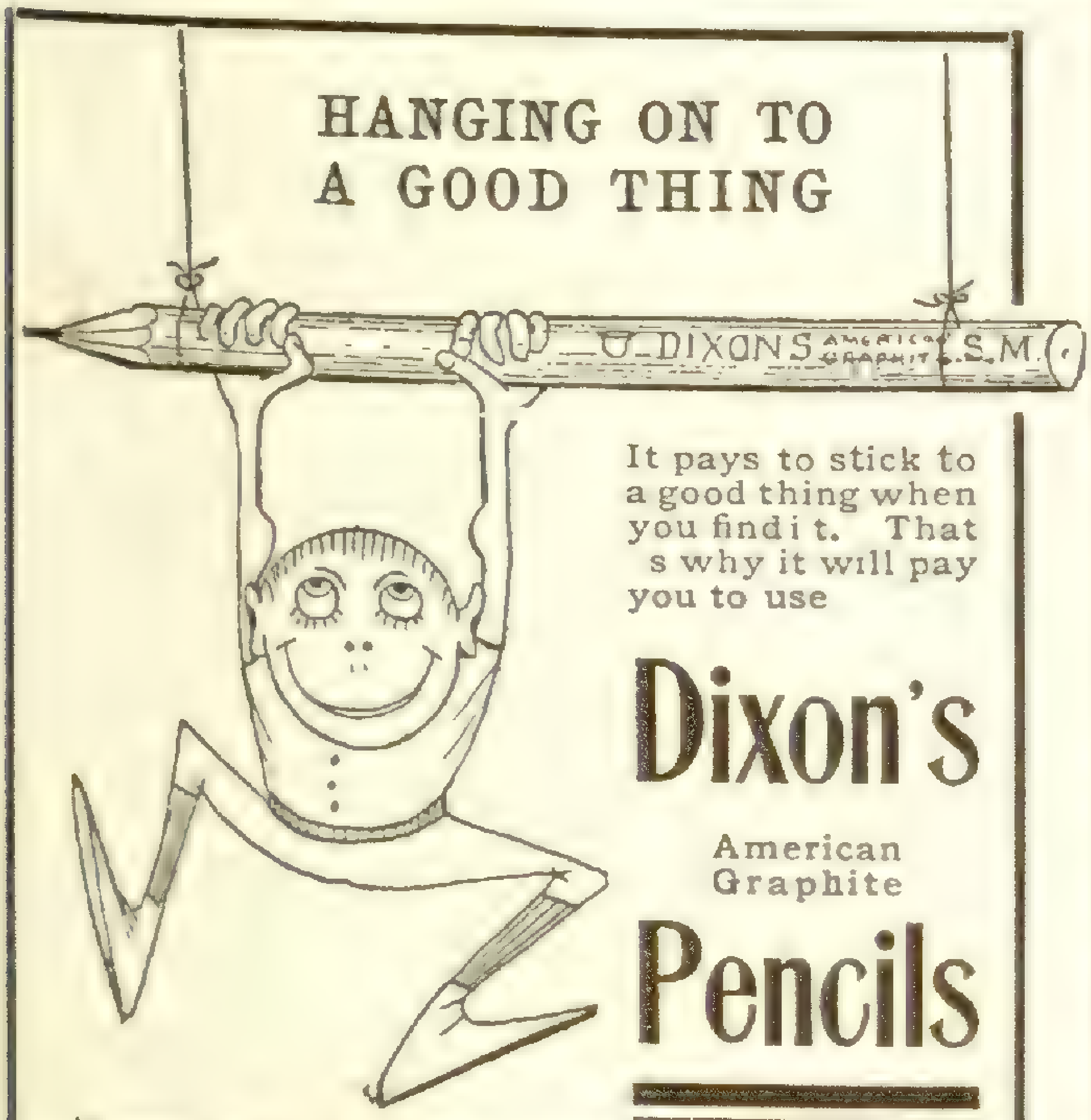

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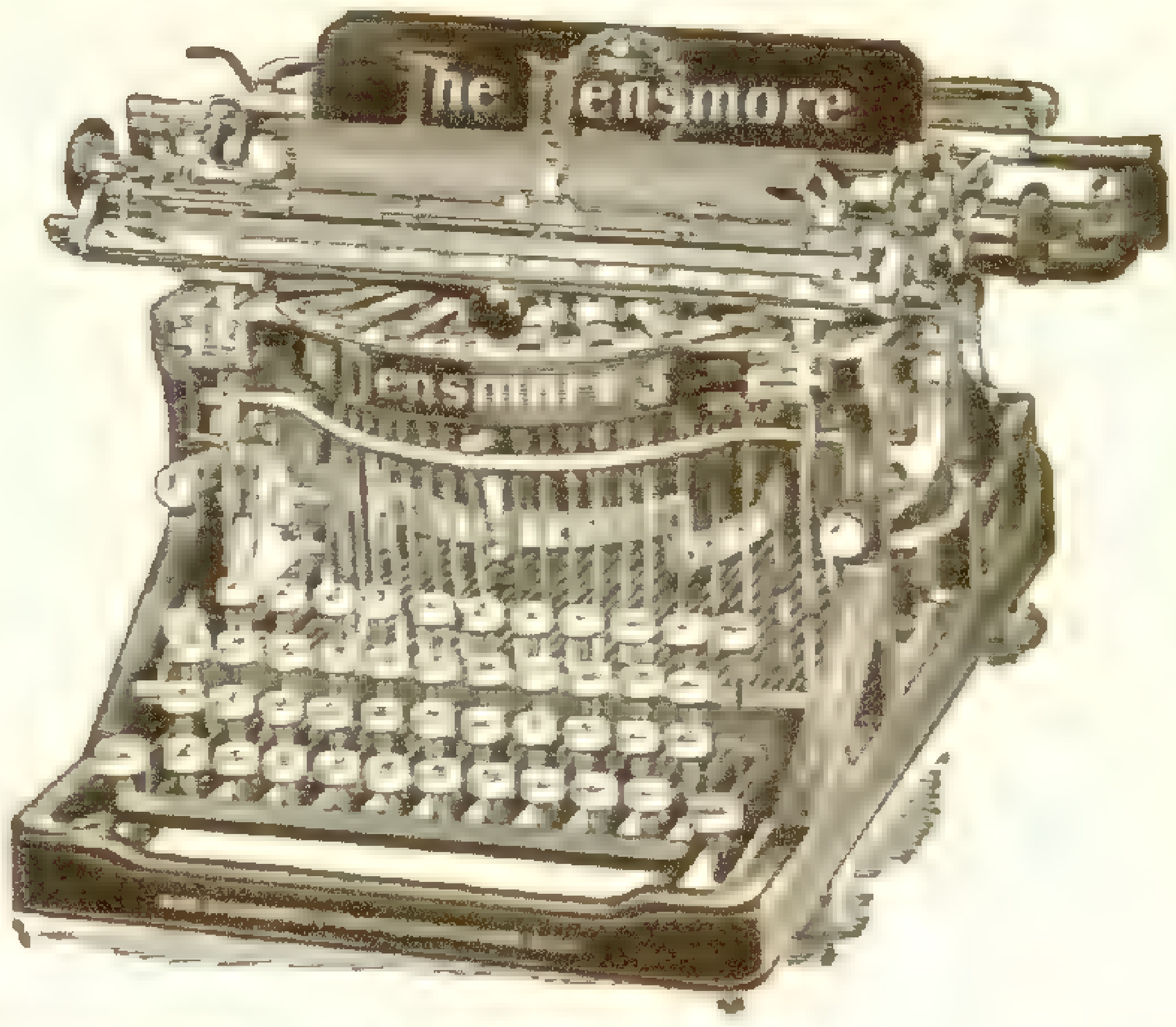

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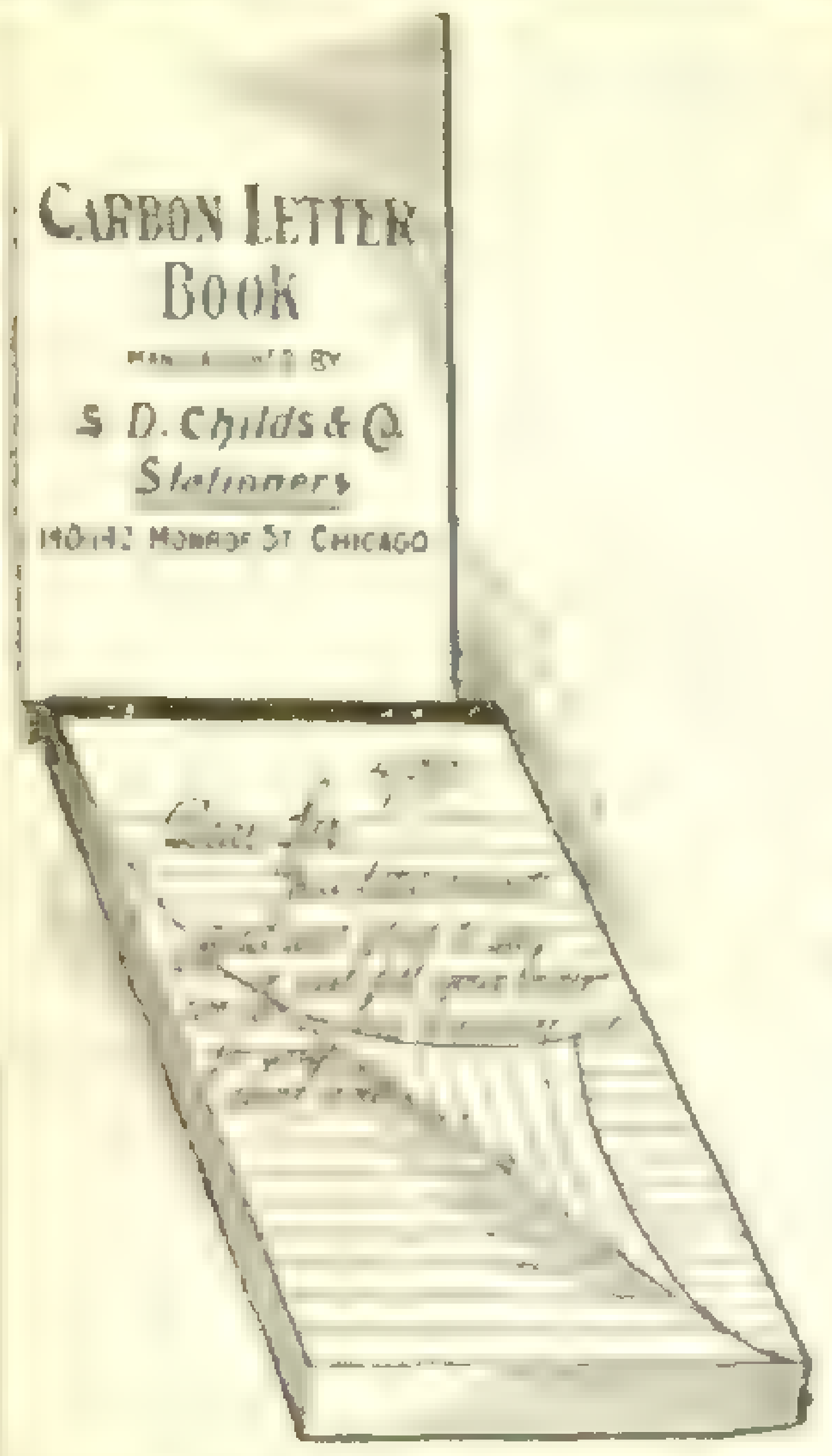

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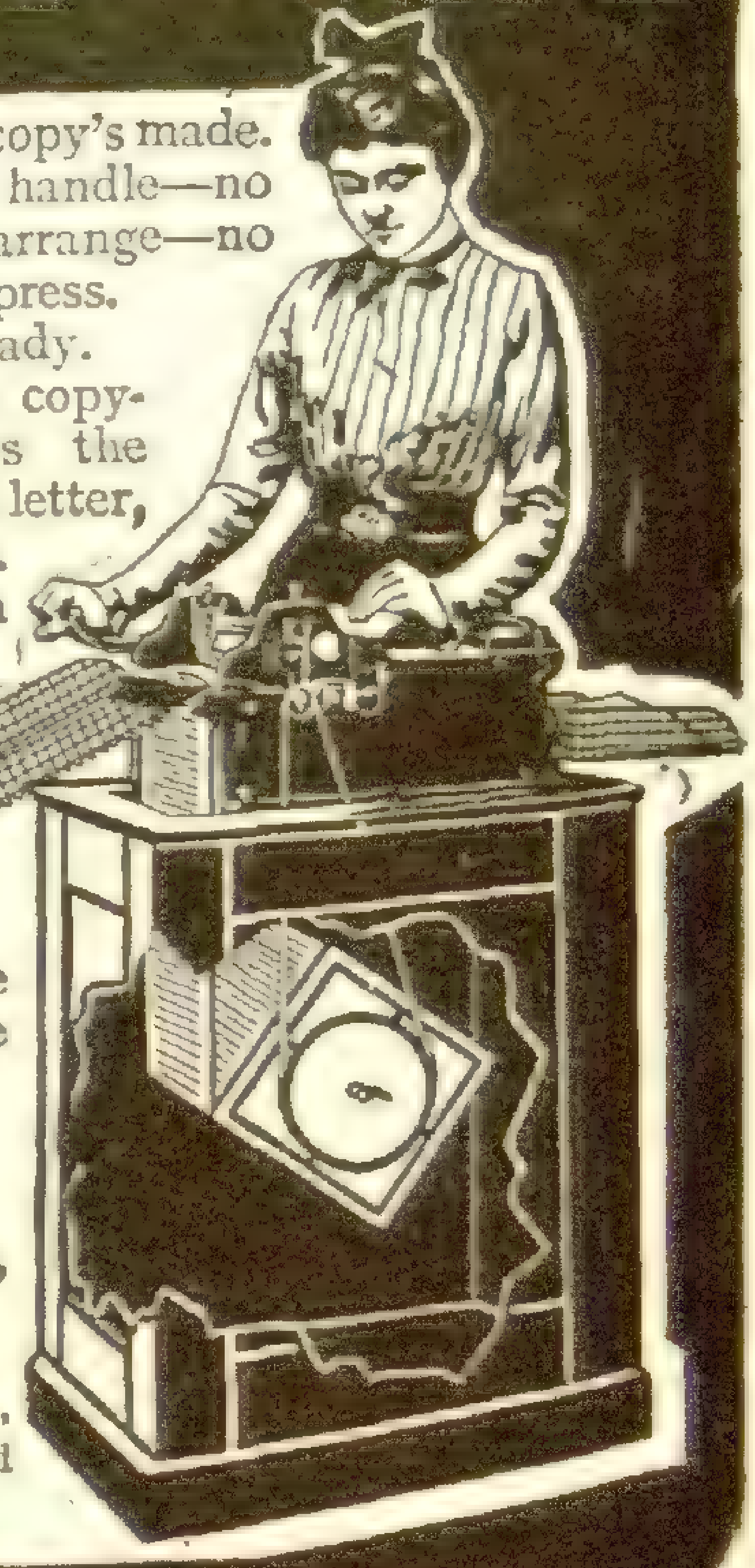

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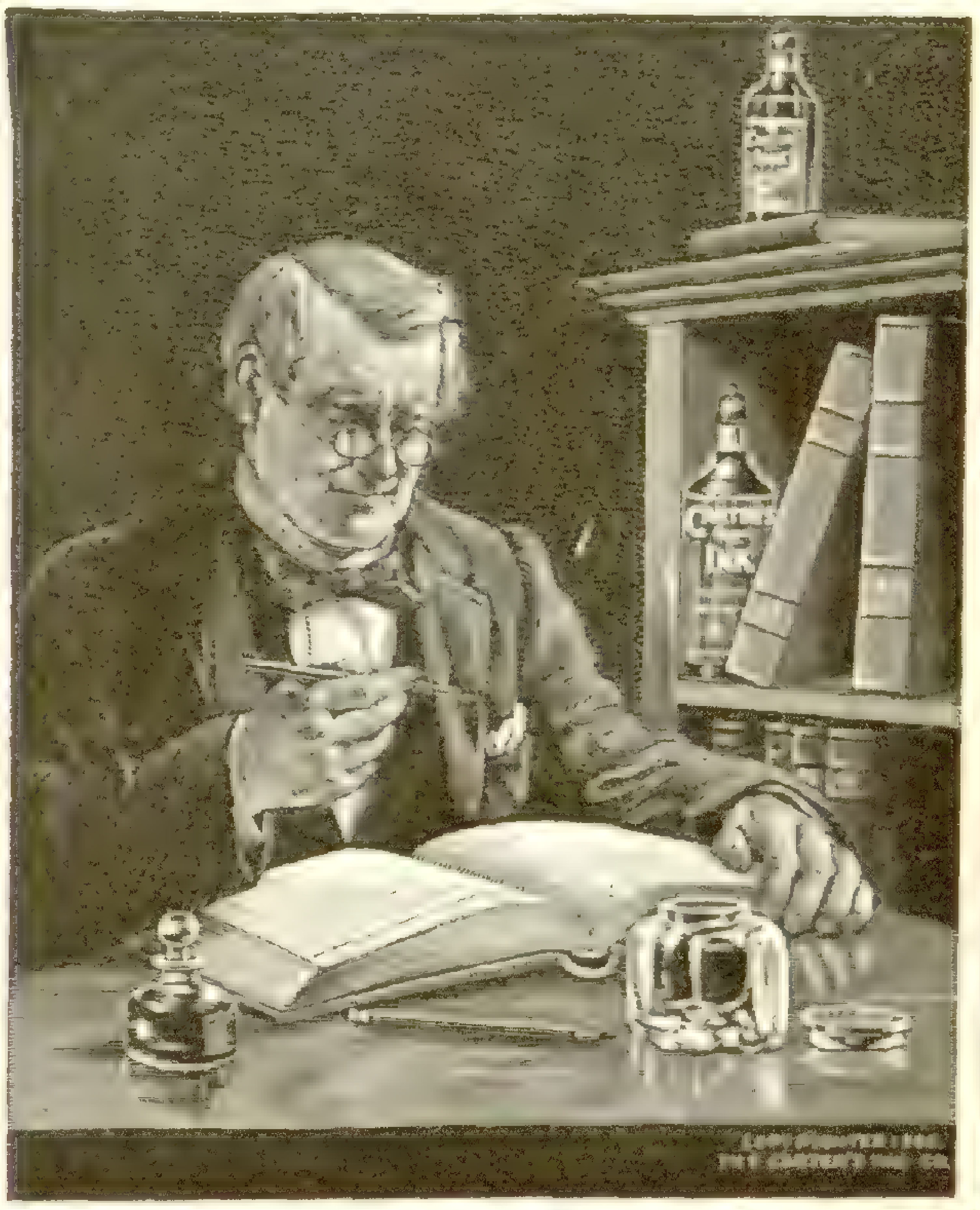

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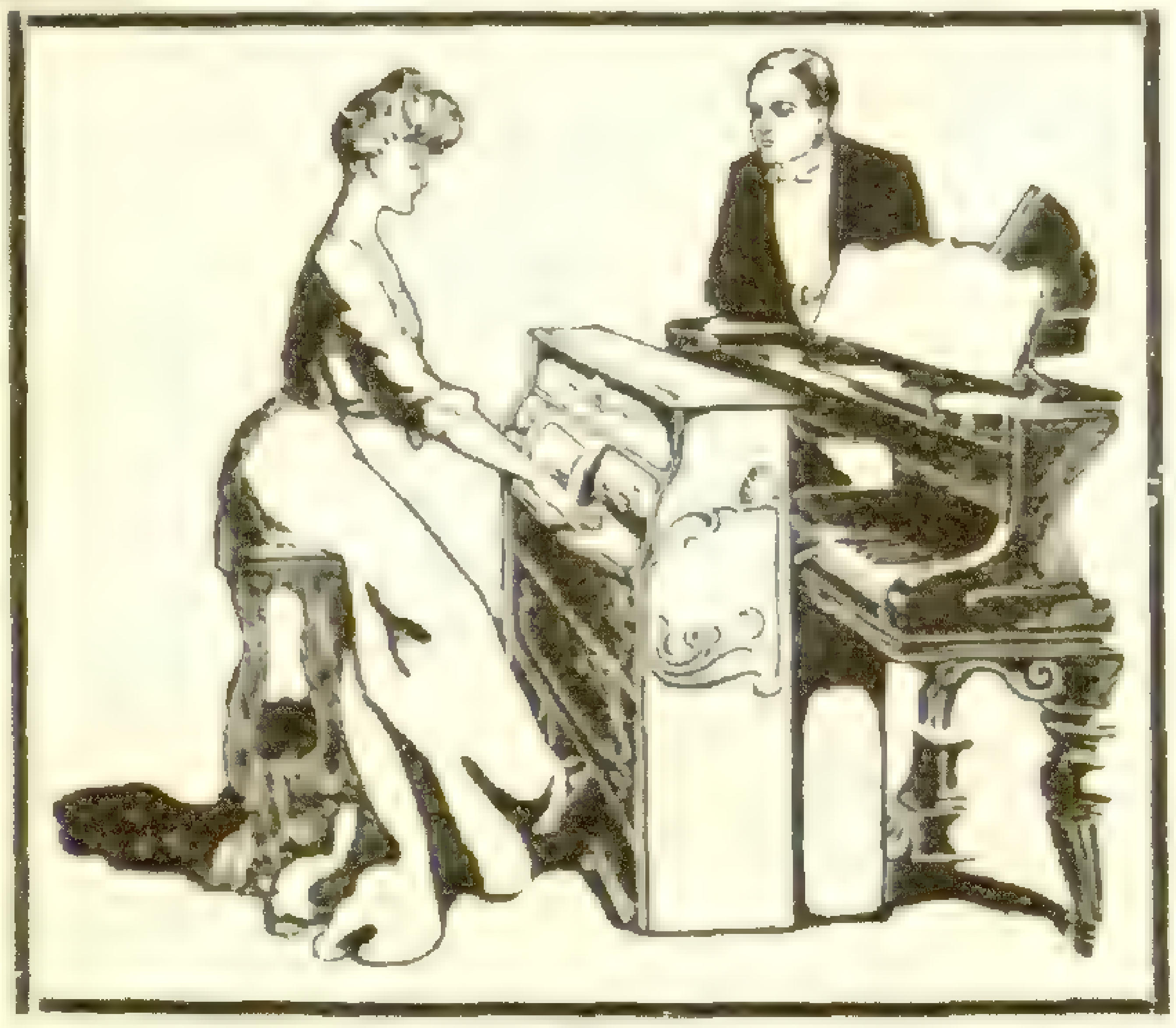

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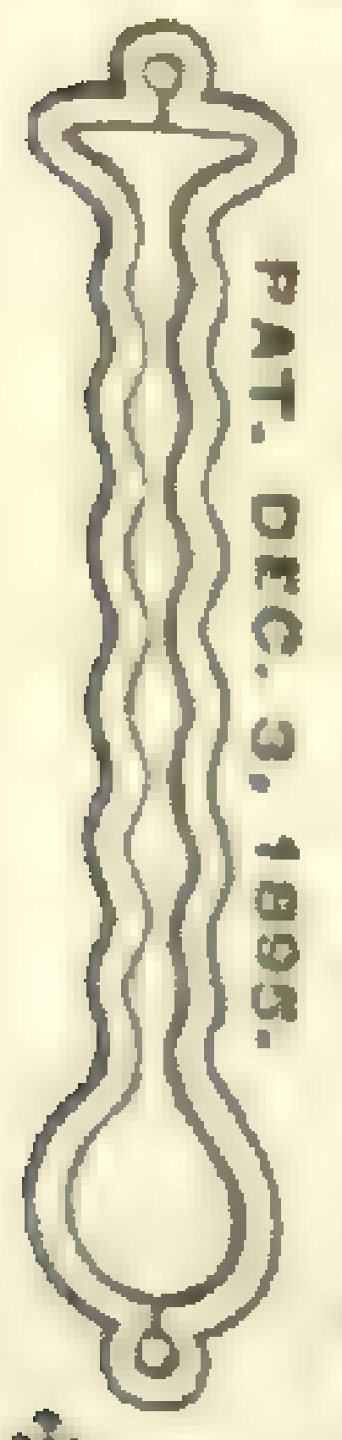

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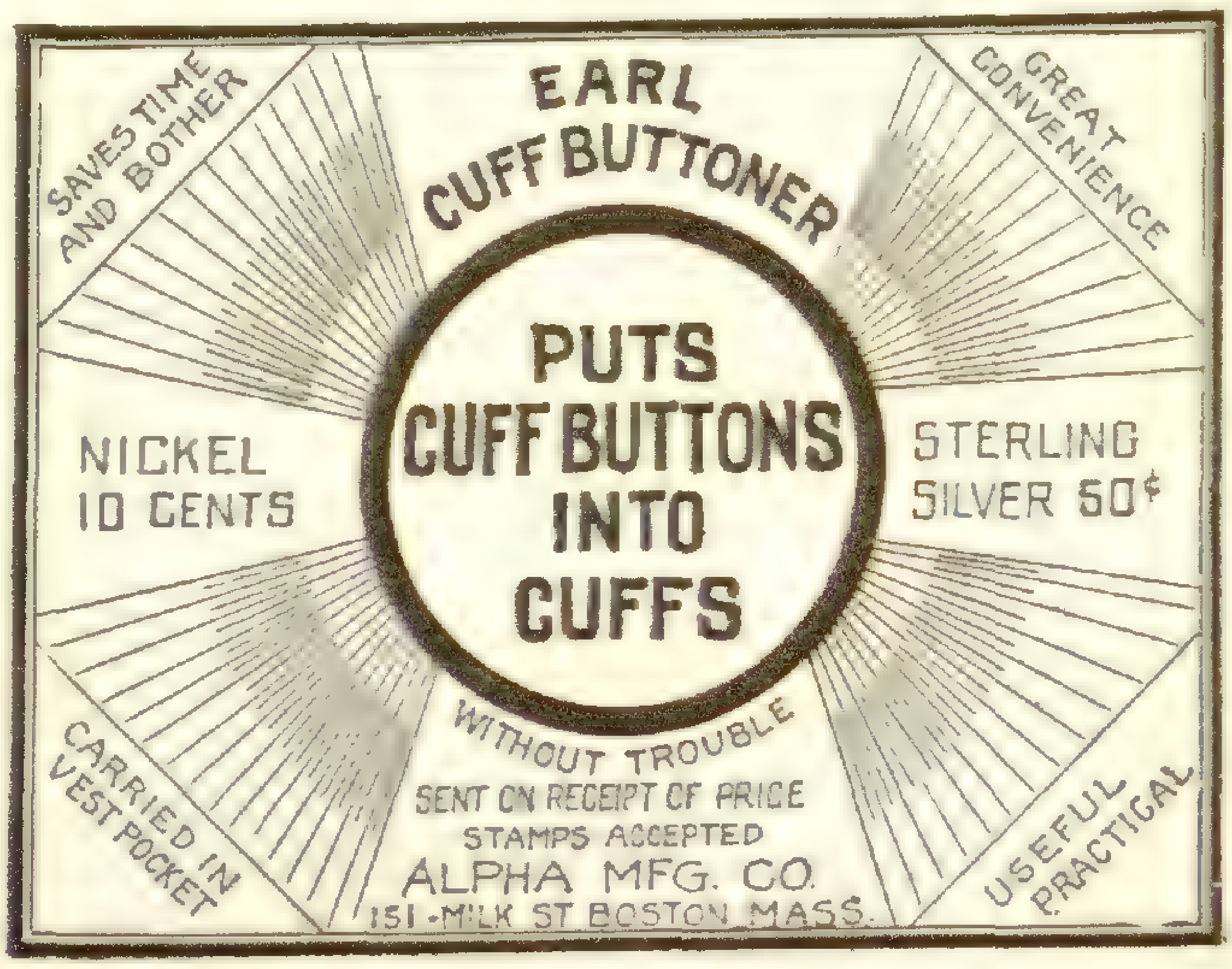

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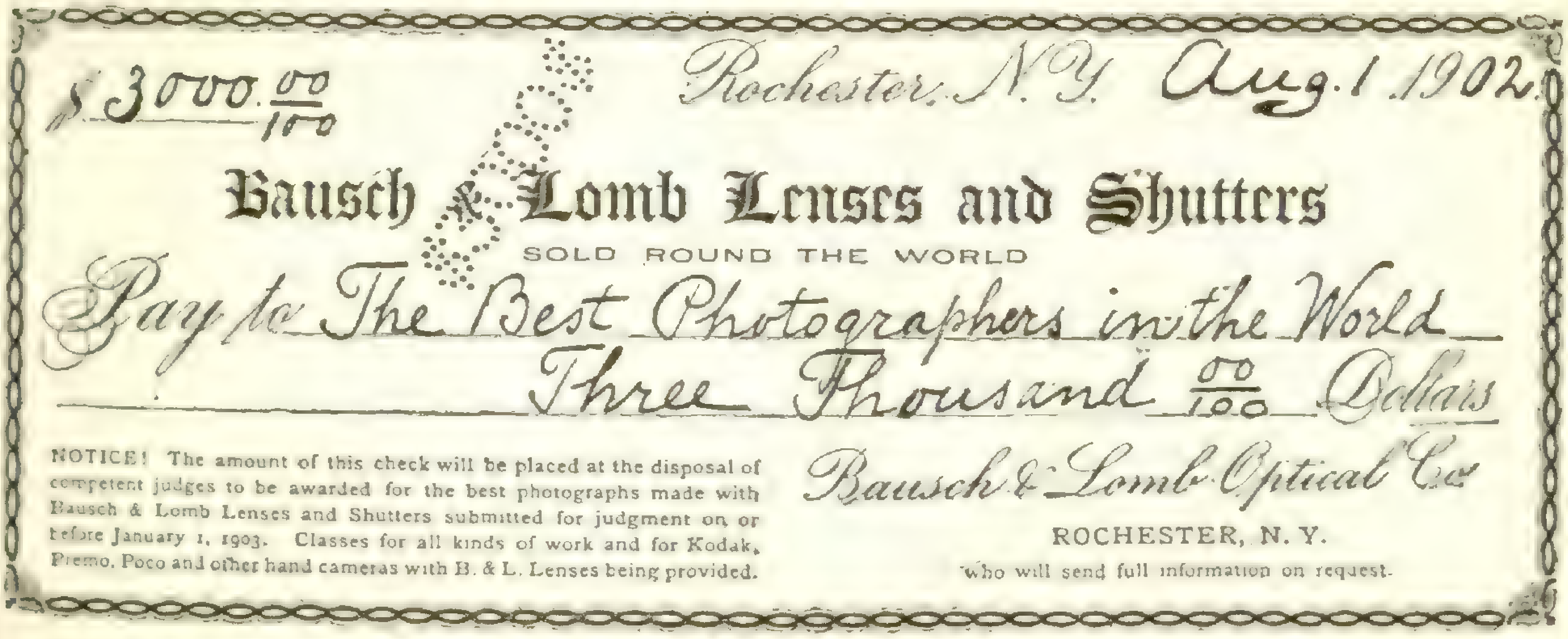

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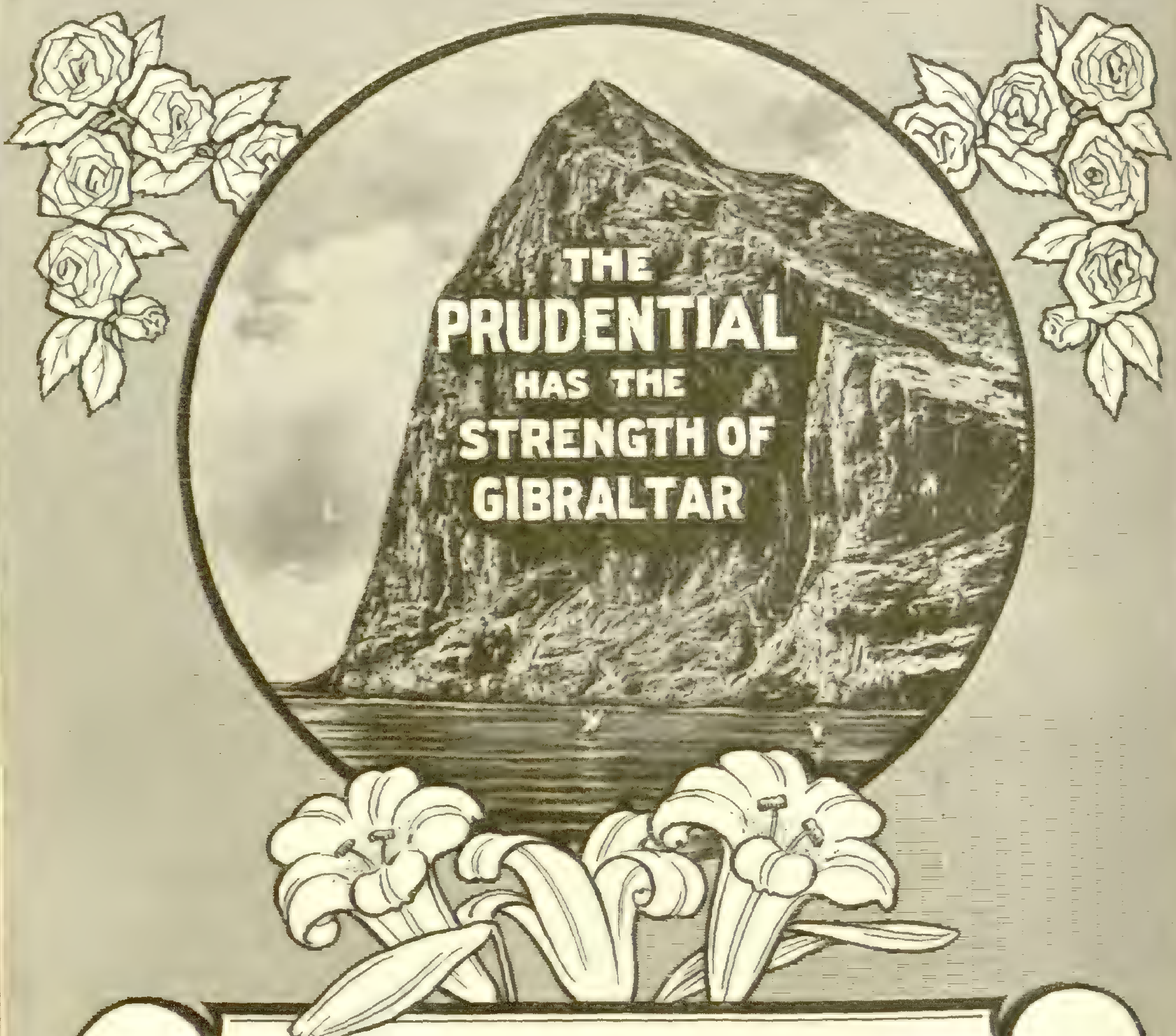
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VOLUME XXXV NUMBER 4

BOTANICAL GAZETTE

APRIL, 1903

OOGENESIS IN SAPROLEGNIA.[1]

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XLVI.

BRADLEY MOORE DAVIS.

(WITH PLATES IX AND X)

ALTHOUGH Saprolegnia is a form of considerable interest in connection with the problem of the so-called multinucleate gametes, nevertheless investigations have not been carried forward upon it with that attention to cytological detail that has recently been given to other Phycomycetes, *e. g.*, Albugo, Peronospora, Pythium, and Sclerospora.

The present paper deals chiefly with the events of oogenesis and a comparison of this process with the development of zoospores. The material employed was apogamous, indeed apandrous, for specimens were chosen entirely free from antheridia to the end that the investigation might be relieved from the dispute on the sexuality of these fungi. However, as will be seen, the results have an important bearing on the well-known binucleate eggs, assumed by Trow to be stages of fertilization. At the end of the paper will be found an account, entitled "Theoretical Considerations," which deals with a number of topics suggested by this study in relation to recent investigations upon Phycomycetes and Ascomycetes.

The material was isolated in pure cultures and cultivated for several months on various substrata, during which time the writer had the opportunity of observing and confirming many of the adaptations recorded by Klebs (1899) in his detailed study of *Saprolegnia mixta.* In this period a number of structural peculiarities appeared, associated with the various sorts of nutrition, and forms arose presenting the characters of three closely related species, *Saprolegnia mixta*, *S. monoica*, and *S. ferax*. The variation was most marked in respect to the presence, absence, or relative quantity of antheridia which are the most important distinguishing marks of these species.

---

[1] Published also in Decennial Publications, the University of Chicago, I. 10:225–257. *pls. 15, 16.* 1903.

The original collection bore oogonia with relatively few antheridia (*Saprolegnia mixta*), and frequently none. By cultivating the form on a rich substratum—raw beef or fresh insects—a much more extensive growth of antheridial filaments was obtained, as in *Saprolegnia monoica.* On other media—boiled whites and yolks of eggs and dried beef—the filaments never produced antheridia, but oogonia were formed abundantly (as in *Saprolegnia ferax*), normal in size and with numerous oospores. After three months all cultures ceased to develop antheridia and the number of oogonia steadily decreased until the cultures reproduced entirely by zoospores. It was always possible to get oospores, as Klebs (1899) has shown, by placing cultures developing zoosporangia under such conditions that the hyphae were no longer submerged. This may readily be done by removing material from water and placing it in a dish of cold agar-agar, which will furnish enough moisture to support the fungus for several weeks. The filaments out of water promptly developed oogonia, even when they had the form characteristic of zoosporangia. Such cultures frequently showed club-shaped oogonia whose eggs were arranged approximately in a line.

Chromacetic acid proved to be the most satisfactory fixing agent, but it must be employed much weaker than the usual formula. One per cent. chromacetic acid caused immediate contraction of the protoplasm, but a solution one-fourth per cent. chromic and one-tenth per cent. acetic acid gave excellent results, and presented advantages of clearness and preservation over weak Flemming, Merkel, corrosive sublimate, sublimate acetic, iridium chlorid, or picric acid. Paraffin sections were cut 3–5 μ thick, and generally stained with safranin and gentian violet. The protoplasmic structures are so minute as to require lenses of the clearest definition, and the Zeiss apochromatic objectives 2^{mm} and 1.5^{mm} with the compensating oculars were employed throughout the investigation.

OOGENESIS.

The accounts of nuclear and cytoplasmic activities in Saprolegnia during oogenesis present some striking contradictions, and leave untouched some phases of a detailed but very significant character. Humphrey (1892) was the first author to apply methods of cytological technique, cutting sections in paraffin, and his studies were followed by the investigations of Trow (1895, 1899) and Hartog (1895, 1896, 1899). The last two authors have expressed very divergent views, asserted with a positiveness that invests their discussions with an atmosphere of personal criticism that need not be reviewed in this paper. It is necessary, however, to consider certain conclusions of the earlier authors with which the present writer is not in accord, and it seems best to do this at the outset, leaving the points of agreement with the present investigation to be taken up in their proper connections.

It is well known that the oogonium of the Saprolegniales contains many times more nuclei than the number of eggs ultimately formed. Humphrey and Hartog believed that the nuclei fused with one another, thus reducing the sum total until the requisite number was present. Trow stated that the number was diminished through degeneration and digestion until it was so small that each egg took but a single nucleus. The writer has found no evidence of nuclear fusions as reported by Humphrey and Hartog, and in general supports Trow's view of degeneration. However, there seems to be a reason, not known to Trow, for the selection of the fortunate nuclei destined to preside over the eggs, and a large part of this paper will deal with that subject.

It is also well known that the eggs of the Saprolegniales are not infrequently binucleate, and sometimes trinucleate. Humphrey and Hartog considered such conditions as merely the final stages in the process of general nuclear fusion, the last pairings whereby the eggs become uninucleate. Trow has made much of these binucleate eggs, believing the two nuclei to be sexual and one of them introduced by an antheridial filament. He has been bold enough to assert sexuality for four members of the group: *Saprolegnia declina*, *S. mixta*, *Achlya americana*, and *A. americana cambrica*. Nevertheless, Trow presents very little evidence that the so-called "male" nucleus comes from the antheridial tube, or that the latter structure ever opens into the eggs. The writer cannot justify Trow's conclusions in this matter, believing them premature as to evidence and illogical as to probabilities. The present study will attempt to show that binucleate and trinucleate eggs are to be expected under the peculiar conditions governing oogenesis.

With respect to cytological details, investigations scattered over so long a period as twelve years could hardly be expected to agree. Hartog studied from entire mounts, yet was able to count chromosomes and observe nuclear figures. Trow sectioned in paraffin, and was at first (1895) completely deceived as to the interior structure of the nucleus and the number of chromosomes. In his second paper, however, Trow (1899) concedes that the nuclei in the antheridia and oogonia divide mitotically, but his figures are far from clear as to detail. Trow was also mistaken in his interpretation of the nucleolus.

The present study will give a more detailed account of nuclear structure and activities than any previous paper. But the most important contribution relates to certain cytoplasmic manifestations that seem to determine in large part the results of oogenesis. These cytoplasmic activities place the process of oogenesis in Saprolegnia in a new light, bringing it into sympathy with conditions in Albugo, Peronospora, and Sclerospora. They are concerned with that cytoplasmic structure termed the coenocentrum.

It is not strange that Humphrey, Hartog, and Trow failed to find the coenocentrum, for its recognition demands exceptionally good fixation and staining. It is probable that Dangeard saw it when he described an oil globule or fatty mass in the center of the egg. It seems possible that Trow may have mistaken it at times for a centrally placed nucleus, to which it bears a certain resemblance that might make the two structures indistinguishable in obscurely stained preparations. The coenocentrum does not appear until the processes of oogenesis are well under way. Previous to this period there are nuclear and cytoplasmic activities of considerable import, and they will be considered first.

It is well known that with the flow of the protoplasm into the swollen tip of a hypha there is apparent that peculiar structure of the protoplasm (*fig. 1*), significant of its streaming movement. The nuclei at that time are very small. When the oogonium is cut off by a septum from the hypha that bears it, the protoplasm becomes distributed almost homogeneously through the interior (*fig. 2*). The nuclei then increase in size, and shortly after show most clearly that detail of structure that is to be expected in the resting nucleus. This structure agrees with the accounts of Harper, Wager, Stevens, and myself for the nuclei in other types of fungi, indicating that the conditions among these lower forms are essentially similar to the nuclear structure of higher plants. As is shown in *figs. 3* and *4*, and especially in *fig. 6*, there is a nuclear membrane inclosing a well-differentiated nucleolus, prominent by its size and staining qualities. Much less conspicuous, but readily demonstrated in well-fixed material, is a loose linin network which contains the chromatic material. Trow's description of a central body containing chromatin and nucleolar matter, but "neither a nucleolus nor a chromosome," must have been founded on inferior preparations. There are certainly no complexities in Saprolegnia comparable to the so-called nucleolus of Spirogyra (Mitzkewitsch, 1898, Wisselingh, 1900).

There is one mitosis in the oogonium, but previous to that event a number of vacuoles are developed which generally result in a peripheral arrangement of the protoplasm around a large central space or vacuole containing cell sap. The vacuoles begin to appear immediately after the oogonium is cut off from the parent hypha (*fig. 2*). They grow larger and run together as bubbles do in soapsuds (*fig. 3*), until finally there are one or perhaps two large vacuoles in the center, and occasionally smaller ones near the edge (*figs. 10, 11*). The protoplasm then lies as a thick peripheral zone, and the nuclei (*fig. 5*) are distributed at varying distances between the oogonial wall and the boundary of the vacuole.

This is the period when one may expect to find the nuclei in mitosis. This event happens to most nuclei at about the same time, and good preparations of this stage of oogenesis are very striking (*fig. 5*). The oogonium is filled with the diamond-shaped spindles inclosed in nuclear membranes. Three stages of mitosis are shown in *figs. 7–9*. It will be noted that the spindle is intranuclear. *Fig. 7* presents the condition just previous to metaphase, with the chromosomes, four in number, at the nuclear plate and the nucleolus lying outside of the spindle. *Fig. 8* is of a stage shortly after metaphase, when the two sets of daughter chromosomes have separated and are about to pass to the poles; the nucleolus is still present, but smaller and staining faintly. *Fig. 9* is of anaphase, the two groups of daughter chromosomes, four in each, lying at the poles of the spindle and the nuclear membrane manifestly about to disappear. The nucleolus probably dissolves; at least I have never been able to follow it much beyond metaphase, but surviving it would of course soon be lost in the granular cytoplasm after the breaking down of the nuclear membrane. Although granules are sometimes present at the poles of the spindles, the latter are generally entirely free from appearances that might suggest centrosomes.

It will be noted that this description of mitosis in Saprolegnia is similar in all essentials to the accounts of Wager (1896), Stevens (1899, 1901), and myself (1900) for Albugo; Wager (1900) for Peronospora; Miyake (1901) and Trow (1901) for Pythium; and Stevens (1902) for Sclerospora. The studies cover a wide range of forms and material. They agree in describing the spindle as always intranuclear and without centrosomes. The nucleolus is a structure always distinct from chromatic material and always, so far as we know, disappearing during mitosis by dissolution or extrusion into the cytoplasm. The chromosomes are derived from a linin network, and after mitosis the chromatin returns to the granular condition generally present in resting nuclei.

Following mitosis, the oogonium passes into a condition that is exceedingly difficult to study. The number of nuclei has been doubled by the division, but the daughter nuclei are much smaller than the parents. A comparison of *fig. 4* with *fig. 10* will illustrate well the change. It is not the small size, however, that makes the examination so difficult, but the fact that these nuclei very shortly show signs of degeneration. Almost all of the nuclei are affected. The nuclear membrane becomes indistinct, and its contents finally lie as granular matter in a clear area that resembles, and probably is, a vacuole. The granular matter is undoubtedly derived in large part from the nucleolus that fragments, but some of it may be chromatin. The study of the steps in this process of general degeneration is especially baffling because the progress is toward a time when the nuclear material becomes indistinguishable from other granules in the cytoplasm.

It is difficult to understand how Humphrey and Hartog could ever have interpreted this process of degeneration as successive nuclear fusions. As Trow pointed out, successive fusions should give more and more conspicuous nuclei, as the material accumulated with each union, and consequently an ever-increasing clearness of conditions. In reality, however, we pass from the stage illustrated by *fig. 10* just after mitosis, to the vague conditions presented in *figs. 11*, *14*, and *15*. The last two figures are of oogonia much older than those shown in *figs. 10* and *11*, and illustrate late stages in the process, when the nuclear membranes have mostly disappeared and the nucleoli and possibly chromatic material lie in vacuoles. Such vacuoles are frequently elongated, and when they contain two masses of deeply staining material there is suggested a stage in nuclear fusion, and such appearances probably deceived Humphrey and Hartog. However, the vagueness of structure and manifest waning of the previous clear definition should have put these observers on their guard. These degenerate nuclei remain for a long time, even after the eggs are fully formed, and it is quite impossible to tell with exactness when they lose their structure and functions.

The eggs are formed during the process of nuclear degeneration described above, and their nuclear structure is really determined by that event. Trow (1899) has given a very good account of the general stages in this process of protoplasmic segmentation, but he did not know the cytological details, and there is reason to believe that he may have been mistaken in his interpretation of certain structures which he considered nuclei. The first external indication of protoplasmic segmentation is the gathering of the contents of the oogonium into denser masses around certain centers, these masses projecting into the central vacuole and destroying that even outline present in earlier conditions of the oogonium (*fig. 5*). The protoplasm between the egg origins is less dense, and presently begins to develop small vacuoles (*fig. 12*), which run together until the egg origins are separated by spaces of considerable size (*fig. 13*). Many of these vacuoles break through the films of protoplasm into the central space, which then appears to have put out extensions toward the cell wall. The protoplasm of the oogonium is exceptionally mobile at this time, and the vacuoles are constantly changing their form and position. In the end the protoplasm gathers more and more closely around the centers of the spore origins, and finally the latter break away from one another at all points of mutual contact (*fig. 13*), and the several independent protoplasmic masses round themselves off as eggs.

The reader will have noticed in the illustrations of this protoplasmic segmentation that each egg origin has a deeply stained center surrounded by delicate rays (*figs. 12–15*). These star-like structures are very conspicuous under low magnification (in *figs. 12* and *13*, 500 diameters), when the center appears to be a single structure. In reality it is not a simple unit, but is always composed of at least two structures, a coenocentrum accompanied by a nucleus. This dual nature is made clear only under high magnification, with clear preparations of very thin sections. I do not think it would be possible to understand the structure from entire mounts such as Hartog's. Hartog probably considered the center as a nucleus alone, and certain of Trow's figures indicate that he gave a similar interpretation. The coenocentrum is really the key to many of the problems of oogenesis in Saprolegnia.

The coenocentrum varies in its minute structure with different periods of oogenesis. It is at first a small body composed of several granules imbedded in dense material, from which a number of delicate fibrils radiate into the surrounding cytoplasm. The structure stains deeply and resembles an aster. After the eggs are fully formed the rays disappear and the coenocentrum grows larger, takes on a spherical form, and resembles a globule of oil or fat. It finally dissolves, sometimes with fragmentation, and completely disappears, in the older eggs. The coenocentrum is thus a structure peculiar to that period of oogenesis characterized by nuclear degeneration and the segmentation of the protoplasm to form the eggs. It bears a most important relation to these two events, which are the most difficult to study in the entire process of oogenesis.

We must begin with the first appearance of the coenocentra. These structures may always be found before the differentiation of the egg origins, at the time when the oogonium is filled with degenerating nuclei. The latter lie scattered through the cytoplasm (*figs. 14, 15*), and exhibit varying degress of dissolution. The young coenocentra are always found in the densest regions of the protoplasm, portions destined to become egg origins, such as are shown in *figs. 14* and *15*. They are very small at first and would scarcely be noticed except for the radiating fibrils that mark their position. They increase in size as the egg origins take more definite form (*fig. 16*).

An examination of *figs. 14–16* shows at the side of each coenocentrum a small nucleus. This structure is very small at early periods of oogenesis (*figs. 14, 15*), and scarcely more clear than many of the degenerating nuclei in the neighborhood; but as oogenesis proceeds the nucleus accompanying the coenocentrum grows larger and increases greatly in staining material (*fig. 16*). When the eggs are fully formed, this nucleus is many times larger than at the first appearance of the coenocentrum, as may be seen by comparing *figs. 17–21* with *figs. 14* and *15*, which are all magnified 1,000 diameters. One would hardly think it possible that the large nucleus present in the center of the mature egg was ever so small as the degenerating nuclei whose remains may be found in advanced stages of oogenesis (*fig. 16*), and sometimes even in the fully formed eggs (*figs. 17* and *23*); but there seems to be no doubt of this. The nucleus destined to preside over the egg is at first indistinguishable in size or structure from many of its neighbors. What should lead to its selection as the egg nucleus? I can see no other explanation than that its position gives it dynamic advantages, enabling it to survive when its neighbors lack the metabolic conditions necessary for nuclei and consequently must degenerate. This conceives the oogonium as too richly stocked with nuclei for the metabolic conditions of oogenesis, and in consequence the field of a struggle of the parts ("der Kampf der Theile," Roux).

What is the relation of the coenocentrum to these events? As we have stated, the coenocentrum is not a permanent organ either in the oogonium or the egg. It appears with the first indications of the egg origins and passes away as the eggs grow older. It is obviously a transitory structure peculiar to the most active periods of oogenesis. To the writer the coenocentrum seems to be the morphological expression of dynamic activities in the oogonium, and especially in the egg origins at the time when these are differentiated. It has the appearance of being the focal point in the center of the egg origins of the metabolic conditions peculiar to oogenesis; and this offers a very plausible explanation of the survival of the nucleus which lies nearest the coenocentrum.

The nucleus most fortunate in its position near the coenocentrum should be greatly benefited if this is a region of the protoplasm more favorably nourished than other parts. It is probable that the coenocentrum even draws toward itself nuclei within a certain sphere of attraction. Nuclei may be found with a pointed end extended toward the coenocentrum (*figs. 16, 20*). It will be remembered that Stevens (1901) showed with great clearness for *Albugo candida* and *A. Tragopogonis* that the nuclei in the immature eggs stretch toward the coenocentra so that their long dimensions are frequently twice the width. The nuclei of

Saprolegnia are too small to present conspicuous morphological evidence of this character; but we have the fact that the favored nucleus is almost always pressed against the coenocentrum which, together with the appearance of the nuclei and what we know of the events in Albugo, makes it quite certain that the coenocentrum exerts a chemotactic influence.

The changes that come over the egg as it matures are illustrated in *figs. 16–21*, which show the usual uninucleate condition of the egg. Binucleate and trinucleate eggs will be described in the following paragraphs. The two most important events of maturation are the increase in size of the nucleus and the gradual dissolution and final disappearance of the coenocentrum. The growth of the nucleus involves not only the extent of the space inclosed in the nuclear membrane (*figs. 17–21*), but also means a great increase in the amount of staining material, chromatic and nucleolar. The latter must be very many times greater in quantity in old eggs than at the beginning of oogenesis (compare *fig. 16* with *figs. 20* and *21*). The coencentrum decreases in size until it becomes a very small globule (*fig. 20*), or it may split up into several granules, which soon become lost in an ill-defined mass of denser protoplasm. The coenocentrum finally disappears, and the contents of the egg then arrange themselves around a central vacuole, with the nucleus taking a peripheral position. This is the structure of the mature egg, and is illustrated in *fig. 21*.

We will now consider some conditions that have given rise to much discussion, namely, the binucleate and trinucleate eggs. They have been found by Humphrey, Hartog, and Trow, and the present study indicates that they may be expected in any member of the Saprolegniales. Trow attached much significance to them as evidence of sexuality, but his conclusions seem to the writer open to much criticism and will be taken up later. *Figs. 22–25* illustrate several conditions that show how easily an egg may become binucleate. Suppose two nuclei lie near enough to the coenocentrum to share about equally the advantages of position. Then it is not likely that either will give way to the other. Such conditions in a young egg are shown in *fig. 22.*

Fig. 25 also represents a pair of nuclei one above the other and both extended toward the coenocentrum, which was fast breaking down. *Fig. 24* is very interesting. In this instance the coenocentrum is the center of a mass of protoplasm considerably larger than the average egg. There are two well-developed nuclei, and the form of the cell suggests the probability that material which ordinarily would have gone into two egg origins has been held together in this instance by the influence of an especially large coenocentrum. An illustration of quite the reverse condition is shown in *fig. 23*, and is remarkable. Here we have presented an egg with two coenocentra, and at the side of each a nucleus. There is no doubt from the age of the eggs that the two nuclei in each of these cases are sister nuclei. It is plain that the processes that work for the segmentation of the protoplasm in the oogonium are complex, not all in the influence of the coenocentrum, nor yet all in the general activities of the cytoplasm.

Give the egg two nuclei with a fair start over their degenerating neighbors, and they seem to be able to exist side by side, not differing, so far as one may see, from the nuclei of uninucleate eggs. The two nuclei may lie far apart, as in *fig. 26*, or so near together that they touch, as in *figs. 25* and *27;* but in no instance—and I have seen a great many binucleate eggs—have I ever observed them fusing. Trow (1899) reported an instance of nuclear fusion in the egg, but the writer thinks we are justified in waiting for confirmation of this observation before attaching to it the importance given by that author.

Trinucleate eggs are somewhat rare in *Saprolegnia mixta.* I have seen hardly more than a dozen, and these were all rather mature examples. I have never been fortunate enough to find young stages, periods comparable to *figs. 22–24* of the binucleate eggs. The three nuclei may be grouped close together in the egg (*fig. 28*), or may lie quite separate from one another (*fig. 29*). There is no evidence that they fuse. The rather meager data at hand indicate that when there are three nuclei in an egg they are individually smaller than the single nucleus in an ordinary egg (compare *figs. 28* and *29* with *figs. 19–21*). This is to be expected, for in general the three nuclei share between them the metabolic possibilities of about the same amount of protoplasm as is in the uninucleate egg. The trinucleate egg probably develops, as does the binucleate, from an egg origin in which more than one nucleus by fortunate position is able to survive the processes of general degeneration.

Let us now examine Trow's position respecting sexuality in the Saprolegniales. It is presented most completely in his 1899 paper. I approach this subject with some diffidence, for it has already been the occasion of detailed discussions of a personal character (Hartog, 1896, 1899). The matter is finally reducible to a question of confidence in Trow's evidence, his account, and his figures. Everyone must admit the possibility of sexuality in the Saprolegniales, but the question for us is, does Trow prove it?

The binucleate egg gave Trow the conviction, as he acknowledges, that fertilization took place through the introduction of a male nucleus into the egg from an antheridial tube. But the present studies show that binucleate eggs are quite common in an undoubted apogamous form, the material being entirely free from antheridial filaments. Moreover, these binucleate eggs have been followed through younger stages back almost to the period of the egg origins, and we know that these two nuclei were sisters in the oogonium. To make this point more plain, let the reader contrast the appearance of the two small nuclei shown in *figs. 22* and *23* with the nuclei in older eggs (*figs. 19-21*), and it will be evident that the former have the size and structure of nuclei in the young oogonium, and not of the fully mature gamete (egg) nucleus. It should also be noted that Hartog's binucleate eggs were also from apogamous material (Hartog, 1898 and 1899, p. 450).

If, then, apogamous material may have binucleate eggs, and the events of oogenesis explain the conditions, we are justified in examining Trow's evidence of sexuality very critically and demanding of it exceptional fulness and accuracy. We are concerned chiefly with Trow's figures, for they should show most exactly what the investigator really saw. I have been impressed with the lack of detail in many of these figures, which has led me to think that Trow may have made a number of mistakes which would quite invalidate his evidence in support of sexuality. *Figs. 43, 44,* and *46,* labeled "female gameto-nuclei," give appearances which are very similar to coenocentra, and I fear that he was not able to separate these structures in his preparations. *Fig. 35* certainly indicates that his material had coenocentra. But the most serious difficulties are encountered in his drawings of male gameto-nuclei (*figs. 45, 46*). These are not clear enough to be convincing; indeed, they seem to the writer to be the remains of degenerating nuclei at the periphery of the egg. Side by side with the structures labeled "male gameto-nuclei" Trow figures bodies, very similar in appearance, which are probably degenerate nuclei. In the face of this uncertainty and seeming contradiction of evidence the illustration of an antheridial filament piercing the egg (Trow, 1899, *fig. 45*) loses much of its weight, and the statement that two nuclei fuse in the center of the egg (Trow, 1899, *fig. 47*) is open to much doubt. The subject is so difficult that there are abundant opportunities for error, and we are justified in asking for much more evidence before accepting such important conclusions.

The writer cannot better sum up his attitude toward Trow's opinions on sexuality in the Saprolegniales than by defining them as *not proven* and *improbable* in the face of the mass of observations upon which botanists have generally agreed that the group is apogamous. The view of apogamy formerly resting entirely on the failure to find antheridial tubes fusing with the eggs is now supported by the present investigation on the details of oogenesis. These show that the binucleate egg, formerly difficult to understand on the theory of apogamy, may arise very naturally in a multinucleate oogonium when the method of oogenesis is as just described for *Saprolegnia mixta.*

The binucleate and trinucleate eggs of Saprolegnia are essentially similar to the multinucleate eggs of *Albugo Bliti* and *A. Portulacae*, and the conditions in the young eggs of *A. candida* and *A. Tragopogonis*, as described by Stevens (1899–1901). The latter, it will be remembered, contain several potential gamete nuclei, but, so far as we know, only one of these becomes functional. But it would not be surprising to find at any time binucleate or trinucleate eggs among species of Albugo that are normally uninucleate.

In concluding, we must lay emphasis upon the importance of the coenocentrum as an index of the activities peculiar to oogenesis in Albugo, Peronospora, Sclerospora, Pythium, and Saprolegnia. Although this structure is probably in large part the expression of activities of the protoplasm as a whole, still there can be no doubt of its material existence. It is difficult to understand how Trow (1901, p. 291) can question this point, except that his figures indicate that fine details of structure were not shown in his preparations.

It would be strange, indeed, if so large a mass of protoplasm as the coenocentrum should not react in turn on the protoplasm that gave it birth. The coenocentrum is not a mass of food material, even though much of its granular substance may be the products of metabolism, and the structure as a whole tropho-plasmic in character. It is protoplasm, and as such must be counted a factor in the subtle processes of oogenesis. Trow's comparison of the coenocentrum to a whirlpool in a river is not good, for there is unquestionably in this structure the expression of chemical phenomena as well as physical. The evidence is very strong from Stevens's (1901) work on Albugo, and the present study on Saprolegnia, that the coenocentrum has a sphere of chemotactic influence on the nuclei in its neighbor-hood.

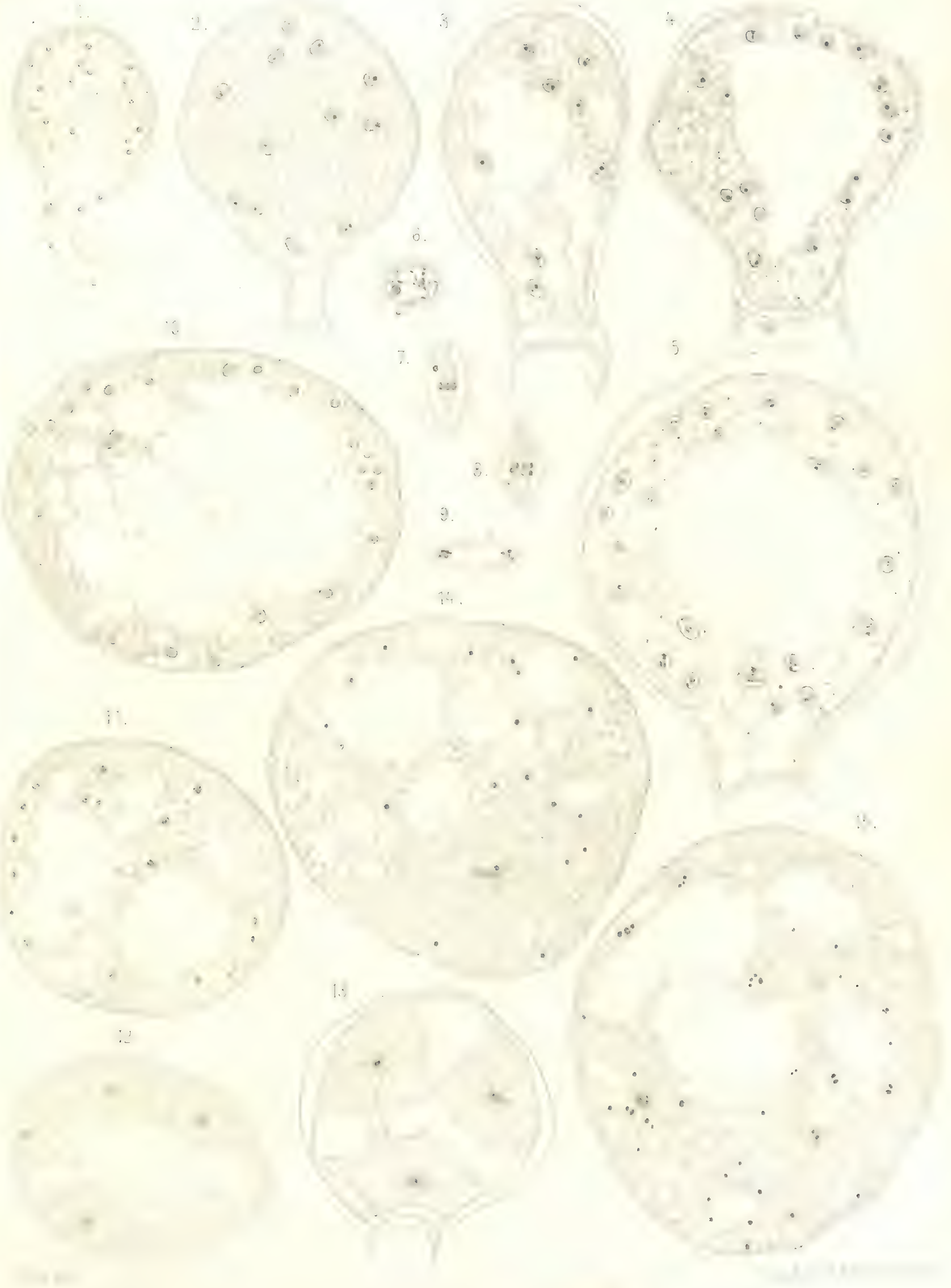
SPOROGENESIS.

Except for a recent paper by Timberlake (1902) on Hydrodictyon, we know little of the details of zoospore formation in either algae or fungi, and the field would certainly repay investigation. The writer examined the sporangium of *Saprolegnia mixta* to contrast the conditions there with the processes of oogenesis, but, the subject not being favorable, little came of the study, except a general confirmation of the accounts of sporogenesis given by Rothert (1888), Hartog (1888), and Humphrey (1892). If the oogonium is the homologue of the sporangium, we should expect a general similarity in the protoplasmic activities of each structure. There is the general agreement that the protoplasm segments by cleavage planes determined chiefly by vacuoles; but beyond this the activities of the two structures have little in common and a great many peculiarities.

As is well known, there is no mitosis in the sporangium. A large number of nuclei are carried into the tip of the hypha by the accumulation of protoplasm there. Vacuoles collect and develop in the center of the young sporangium (*fig. 30*), and flowing together form a large central space inclosed in a vacuolar membrane (*fig. 31*). The nuclei then lie scattered in the peripheral layer of protoplasm, and presently clefts appear which work outward between the nuclei from the central vacuole (*fig. 32*). The clefts divide the protoplasm so that it is cut up into polygonal areas, with clearer regions between. These are the zoospore origins, and each contains a nucleus.

Rothert's explanations of succeeding conditions, which have also been confirmed by Humphrey and Hartog, seem entirely satisfactory. The sporangium is in a state of turgor when the clefts arise and push their way from the central vacuole toward the periphery. They finally reach the cell wall and immediately make possible the relief of the fluid in the central vacuole. There is at once a very evident decrease in turgor, which has an interesting effect on the appearance of the spore origins. The polygonal areas run together, and the whole sporangium becomes again almost homogeneous in structure. This means that the contraction of the sporangium brings the spore origins so close together that the clefts become almost obliterated. The spore origins also swell. They then begin to separate slowly, preliminary to their being finally rounded off as zoospores. There is a period when the small masses of protoplasm form a very irregular network through the sporangium (*fig. 33*), and this is followed by a more regular arrangement (*fig. 34*), in which the spore origins are connected by very delicate protoplasmic strands. The latter are finally broken and the bodies round off as zoospores.

The writer searched persistently in the sporangium for cyto-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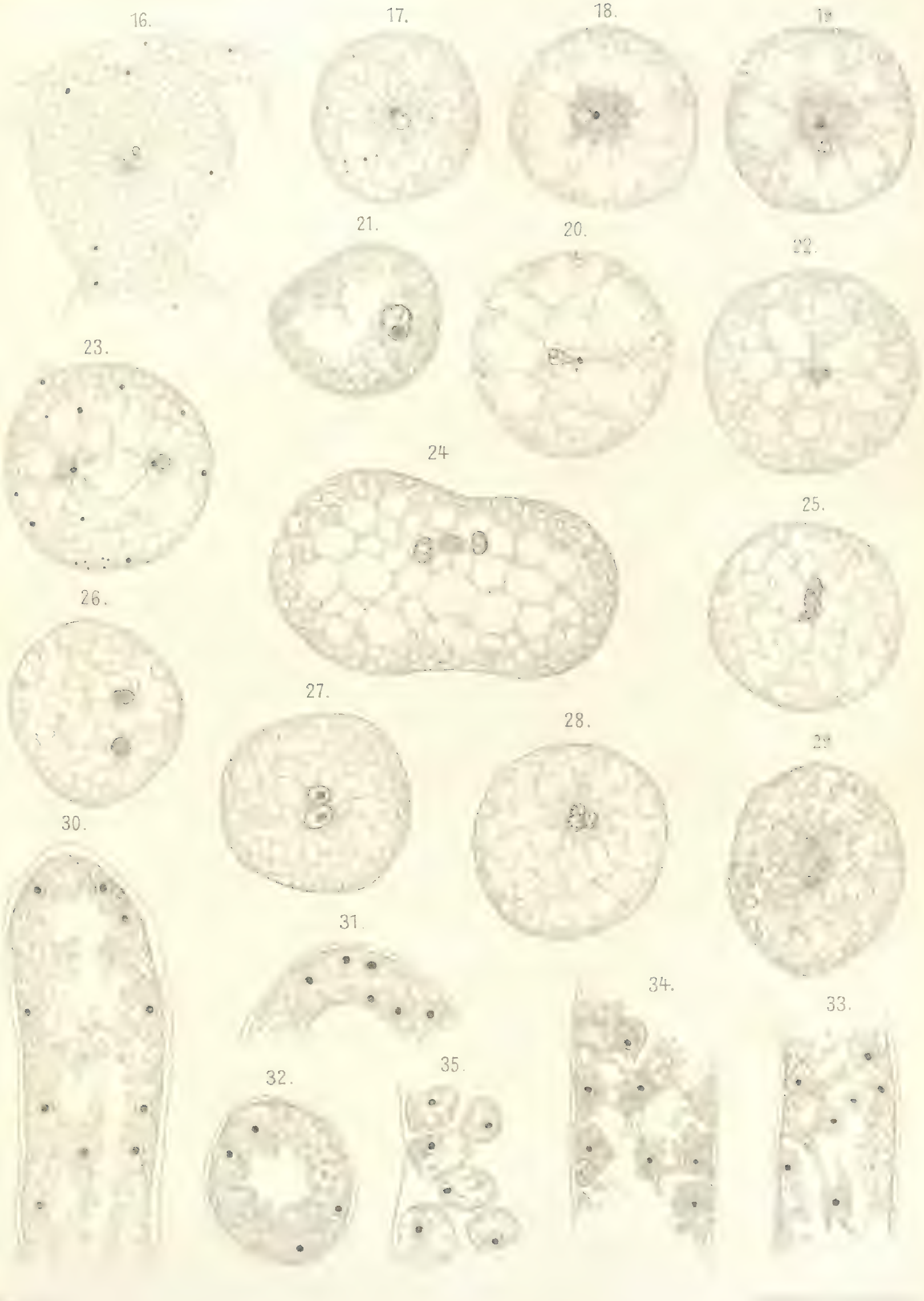
DAVIS on SAPROLEGNIA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plasmic centers around which the process of segmentation might proceed, in the hope that light would be thrown upon the problem of the coenocentrum, but the examination brought forth no evidence of such structures in the sporangium. The nuclei themselves seem to be the ultimate centers of segmentation. The coenocentrum, therefore, so far as we know, is a structure peculiar to the oogonium.

[*To be concluded.*]

THE BEHAVIOR OF THE CHROMOSOMES IN THE SPORE MOTHER-CELLS OF HIGHER PLANTS AND THE HOMOLOGY OF THE POLLEN AND EMBRYO-SAC MOTHER-CELLS.

DAVID M. MOTTIER.

(WITH PLATES XI–XIV.)

THERE is probably no other problem which has presented greater difficulties to the botanical cytologist than the behavior of the chromosomes during the two successive nuclear divisions in the spore mother-cells of the higher plants. This is at once apparent, even to those who are not specialists in this field, from the different interpretations which have been advanced from time to time, and from the various and contradictory doctrines that are still held by different investigators.

From the zoological side, we are indebted to Flemming and his students for the first correct interpretation of the behavior of the chromosomes in the two successive nuclear divisions in the spermatocyte of Salamandra.

Flemming designated the first of these divisions as "heterotypic" and the second as "homotypic." The first division in Salamandra is characterized by a long period of growth of the cell and nucleus during the prophase, the appearance of the reduced number of chromosomes and their double longitudinal splitting; the first longitudinal fission taking place during the prophase and the second during the metaphase or anaphase.

The striking parallel between the first two mitoses in the micro- and macrospore mother-cells of higher plants and those of the spermatocyte of Salamandra has frequently been pointed out, and the terms heterotypic and homotypic have been appropriately applied to them.

Recent investigations have shown that in the spore mother-cells of certain higher plants the first mitosis is especially characterized also by a long period of growth during the prophase, the first appearance of the reduced number of the chromosomes, and the double longitudinal splitting of the latter.

It is chiefly upon the behavior of the chromosomes during these divisions that the great diversity of opinion rests, and this is not surprising when one realizes the complexity of the problem and the difficulties attending its investigation. However, in certain plants the double character of the daughter segments during the anaphase of the first nuclear division in the pollen mother-cell is so evident that one is surprised that it has been overlooked for so long a time and by so many observers. In all probability, this phenomenon may have been observed by earlier investigators, but as its significance was not understood the double nature of the daughter chromosomes may have been considered more apparent than real.

Heuser ('84) seems to have been the first to call attention to the double character of the daughter chromosomes in the diaster stage of *Tradescantia virginica*, but he interpreted the separation of the daughter segments during metakinesis of the first mitosis as a transverse division.

In 1895 Strasburger, basing his conclusions largely upon a study of Larix, properly explained the V-shaped daughter chromosomes, which so frequently appear during the anaphase of the first division in the spore mother-cell, as the result of a second longitudinal splitting taking place at right angles to the first. Each V-shaped element, therefore, represents two granddaughter chromosomes which remain attached at the ends to which the spindle fibers are fastened, while the opposite ends diverge, forming the V.

Two years later, Strasburger together with the writer abandoned the doctrine of the double longitudinal splitting, and the V- and U-shaped elements were explained as the result of a folding together of the chromosomes, or as a bending during metakinesis or previously, a view which had been held by other observers. Our conclusions were based largely upon the ring- or loop-shaped chromosomes which often occur in other plants, such as Podophyllum and Tradescantia, and upon phenomena observed in the second mitosis of the embryo-sac of *Lilium*

Martagon. In one respect we were correct, for in many cases the V- or U-shaped chromosomes are produced by a bending, either before or during the anaphase, but the fact that the V's and U's are double was overlooked.

Guignard ('99) found that in *Naias major* a second longitudinal fission occurs during metakinesis of the first nuclear division of the pollen mother-cell, and that each retreating daughter chromosome is composed of two rod-shaped granddaughter segments.

Grégoire ('99), in the same year, observed the same to be true for Lilium and Fritillaria.

Strasburger (1900), upon reinvestigating the subject in several different genera and species, found also that his explanation of 1895 was the correct one; for in all plants examined there occur during the first mitosis in the pollen mother-cell two longitudinal divisions of the chromatin, the first occurring, as the writer had very clearly shown, during the early prophase, the second during metakinesis, or while the daughter chromosomes are on their way to the poles. The second longitudinal splitting is a preparation for the second mitosis, which in Lilium does not pass completely into the structure known as the resting stage.

Since the appearance of the publications above cited, I have taken up the problem again, and have followed carefully both mitoses in the pollen mother-cells of *Lilium Martagon, L. candidum, Podophyllum peltatum*, and *Tradescantia virginica*, together with the corresponding nuclear divisions in the embryo-sac mother-cell of *Lilium Martagon.*

As regards the pollen mother-cell, I am able to confirm the results of Strasburger and the two French observers, namely, that during the first mitosis two longitudinal divisions of the chromosomes take place. I hope, however, to present more clearly certain details of the second mitosis in the pollen mother-cell, together with certain facts which have hitherto been too lightly touched upon, and add also the evidence which the embryo-sac contributes to the problem.

The earlier prophase of karyokinesis has been described in minute detail, and I have nothing to add to my former account of the process (Mottier, '97). As soon as the chromatin spirem, which has split longitudinally, has segmented into the chromosomes, each chromosome consists in Lilium of two rather long daughter segments. These segments may be variously oriented toward each other even in the same nucleus. Sometimes they may be separated entirely from each other, being connected only by delicate threads; but, as is generally the case, they are more or less closely applied and twisted upon each other (*fig. 1, a*). Again, they may be attached to each other near the middle or at one or both ends. In the latter case, the free ends may diverge variously (*fig. 1, b, c*). It frequently occurs that the opposite ends adhere, while the middle portion bends outward to form loops or rings (*fig. 2, b*). In the majority of instances, it is clear that the daughter chromosomes are twisted upon each other, and to this fact is due many of the peculiar forms to be observed in the spindle stage.

Between the time of the segmentation of the chromatin spirem and the mature spindle, the chromosomes contract somewhat, becoming thereby shorter and thicker. They may lie distributed along the nuclear membrane or irregularly scattered in the nuclear cavity. At this stage, however, we frequently find the daughter segments so oriented toward each other as to present the various other forms often observed in the nuclear plate, such as loops, rings, X's, Y's, etc. With the development of the spindle, which occurs in precisely the manner described in my earlier paper (Mottier, '97), the chromosomes are gradually oriented in the nuclear plate (*fig. 3*). So far as can be determined with absolute certainty, each chromosome, up to the stage of the mature spindle, is composed only of two daughter segments, although in some cases a trace of the second longitudinal fission may be seen in the segments. It was this phenomenon that strengthened my former view that the chromosomes folded upon themselves during the development of the spindle.

As has been shown by numerous observers, the chromosomes arranged in the nuclear plate present various forms and various modes of attachment to the spindle fibers. In Lilium the most frequently occurring form of chromosome at this stage is that of the two segments rather closely applied and twisted upon each other. They are attached to the spindle at the end, and stand radially to its long axis (*fig.* 2, *a*). The segments are frequently straight and not twisted upon each other.

Numerous instances are met with in which the daughter segments remain adhering at both ends, but separate near the middle, so that a ring or loop results (*fig.* 2, *b*). The segments may separate at one end, when an open ring or loop is formed. Cases are not infrequently observed in which the segments of the ring-shaped chromosomes bend near the middle so that the free ends are brought nearer together, and we have a ring or loop partly folded upon itself. This is true in a measure in *fig.* 2, *b*. The ring- or loop-shaped chromosome is attached to the spindle near one end of the daughter segments, or at a point midway between the ends, rarely at the ends; although such a mode of fastening was occasionally observed. As a rule, however, the rings or loops are placed tangentially upon the spindle.

When the daughter segments diverge at one end but remain closely applied for the remainder of their length, a Y-shaped chromosome results (*fig.* 2, *h*), which is fastened to the spindle as indicated in the figure. An X-shaped chromosome is formed when the segments lie variously crossed with one or both ends diverging (*fig.* 2, *f*). X-shaped chromosomes are not rare in which the segments are so closely applied at one end as to give the impression of a loop formed by the chromosome folding in such a way that the opposite ends are brought together (*fig.* 2, *g*). In fact all intermediate forms are found between that of *f* and *g*. Finally chromosomes such as *fig.* 2, *c*, *d*, *e* are of frequent occurrence. In this form of chromosome, the segments, which are more or less twisted upon themselves, are usually fastened to the spindle fibers near one end or at the middle. Such chromosomes are, as a rule, oriented tangentially upon the spindle.

As regards the development of the spindle, I have nothing to add to my account of this process already published (Mottier, '97, '98). There are no individualized centrospheres or centrosomes. It may be mentioned further that in the mature spindle the following arrangement of fibers is to be observed: bundles of fibers extend from the chromosomes to the poles, a complex of fibers running uninterruptedly from pole to pole, the central spindle fibers, and those which diverge from the poles toward the plasma-membrane (*figs. 4, 5, 7*).

During metakinesis the daughter segments undergo a longitudinal fission which is at right angles to the plane of the first longitudinal splitting. In favorable cases, the result of this second longitudinal fission may be seen just as the daughter segments begin to separate or a little earlier, but as a rule the double nature of the daughter chromosomes is not evident until they have separated somewhat (*fig. 5*). As the daughter chromosomes separate, the granddaughter segments remain attached at the polar ends while the opposite ends generally diverge, and the well-known V-shaped structure is the result. In *fig. 5* it is clear that the V-shaped daughter chromosomes owe this form to the manner in which they are attached to the spindle and to the longitudinal fission of each daughter segment into granddaughter chromosomes. The chromosomes at this stage are confusing, because of the distortion of the segments due to the former twisting, and because of the fact that different forms of chromosomes with their various modes of attachment to the spindle occur in the same karyokinetic figure. It should never be forgotten, however, that under the circumstances just described in *fig. 5* the daughter chromosomes as they pass toward the poles are not always V's, but frequently straight or nearly straight rods which lie parallel and closely applied to each other (*fig. 8*, the chromosome in the middle). If the chromosomes be fastened to the spindle by the ends, the daughter chromosomes will form V's only when the equatorial ends of the granddaughter segments diverge.

In such chromosomes as *fig. 2, c. d, e*, it is apparent that the retreating daughter chromosomes may be either in the form of a U or V, and that this form will arise as a bending of the segments during metakinesis, since they are not attached by the ends. But such U's or V's are always double, as is shown in *fig. 6* on the left, and in *fig. 8*. Both limbs of the U or V are not necessarily of the same length, for there is every gradation between these forms and straight rods with slightly hooked ends.

The double character of the U-shaped daughter chromosome is not always very evident. Sometimes the granddaughter segments give the impression that one chromosome is lying just beneath another. Such phenomena were frequently observed by myself during my first investigation of the subject and were interpreted as two different daughter chromosomes, one lying directly below the other. Chromosomes which have the form of *fig. 2, c, d, e*, will probably yield U- or V-shaped elements as a result of being bent during metakinesis. The X and Y forms (*fig. 2, g, h*) will probably give rise also to V-, rod-, or hook-shaped elements. In *fig. 6*, the chromosome on the left was attached to the spindle near the middle, and each daughter segment consists of two similar U- or hook-shaped granddaughter elements. This chromosome may have been originally in the form of *fig. 2, b, e*, or the two daughter segments may have sustained the same relation to each other as in the figure, being in contact only at one end. In the chromosome at the right (*fig. 6*), the attachment was at the end, so that each daughter chromosome consists of two similar rods more or less bent or undulating.

Fig. 7 shows a typical nuclear figure in the anaphase. Here it is clear that the chromosomes were attached to the spindle by the ends, or very near the ends, so that as a consequence of the second longitudinal fission each daughter chromosome consists of two rod-like, straight, or variously bent or hooked granddaughter elements, which adhere at the polar ends, while the equatorial ends diverge. Sometimes the polar ends are so closely adherent or fused that the daughter chromosomes may appear as continuous V-shaped objects. In such cases it is often impossible to determine in what manner the V-shaped chromosome was produced, and it is this fact that has led to incorrect interpretations. The close adherence or fusion of the granddaughter segments at the ends turned toward the poles may be due to the manner in which the segments are attached to the spindle, as both granddaughter segments are fastened to the same bundle of fibers.

As the pairs of granddaughter elements arrive at the poles, they approach each other so closely that generally the identity of the individual elements can not be recognized, but in many cases the reconstruction of the daughter spirem can be followed with precision. I have already shown how the free ends of the daughter chromosomes unite to form a single daughter spirem. (*fig. 10*). If the granddaughter segments form V's, the ends at the angle fuse first, in case this has not already happened, and then follows the fusion of the free ends. But in those cases in which the granddaughter segments are U-shaped and closely applied to each other side by side, it is evident that they must first separate in order to unite end to end, for the spirem was always found to be single.

At first the spirem is contracted, consisting of short turns, but soon after the nuclear membrane is laid down, the spirem becomes hollow and more regular and uniform.

Grégoire ('99) states with emphasis that in *Lilium candidum* and *L. speciosum* especially the chromosomes maintain their identity throughout in the daughter nucleus; that a continuous spirem is not formed but only a pseudo-spirem. My studies have included *L. candidum* and *Fritillaria persica*, and in these, as well as in *L. Martagon*, nothing is clearer than the fact that the chromosomes do lose their identity in the daughter nucleus.

The chromatin thread is not at all times an even and uniform spirem. During the reconstruction of the daughter nucleus, the chromosomes show a tendency to reticulate, becoming somewhat lumpy, and the spirem, if we may so designate the chromatin at this stage, is interrupted in many places. This is true especially just after the spirem begins to become more hollow, and the phenomenon may be regarded as a tendency to pass into the structure of the resting nucleus. The tendency of the nucleus to go into the resting stage is more pronounced in the embryo-sac and in other plants to be mentioned in a later paragraph.

In some cases and at a later stage a large part of the daughter spirem is quite regular, presenting a series of long and more or less uniform turns, so that when seen from the pole, the spirem appears in the form of a wreath or crown (*fig. 11*). This regularity is rather the exception than the rule, since in the majority of cases much of the spirem consists of irregular turns varying in size. It seems probable that were all the granddaughter elements rods, which form V's, the spirem would be quite regular; but, as often happens, when these elements arrive at the poles in the form of V's, double U's, and contorted rods intermingled, a very irregular spirem must result.

Strasburger, Guignard, and Grégoire state without reserve that the loops of the spirem (*fig. 11*) represent the V's and U's of the previous karyokinesis. This may be true, but the statement for Lilium, and more especially for other plants to be mentioned later, is purely a deduction. The spirem is often, if not always, continuous, as Strasburger also asserts, and the identity of the individual chromosomes is lost. It is true that in Lilium the daughter nucleus does not pass into that structure known as the complete resting stage, yet during the construction of the daughter spirem the chromosomes do to some extent become reticulated, so that the second mitosis may have for its purpose something more than the equal distribution of the granddaughter chromosomes to the four granddaughter nuclei. This seems especially true in those plants in which the daughter nuclei pass into the resting stage or approach it more closely than in Lilium.

The division of the daughter nucleus in the pollen mother-cell of Lilium and in other phanerogams as well, has been a stumbling block to every cytologist who has studied the problem. So complex is the process, especially the behavior of the chromatin, and so numerous are the difficulties attendant upon its study, that it is little wonder that errors have been made and that several different explanations have seemed at the time equally correct.

As I have shown in former publications, the spindle of the second mitosis develops as a multipolar structure, arising in a manner similar to that of the first division. Attention was called to the fact also that the spindle fibers may enter the nuclear cavity before the spirem is completely segmented into the chromosomes, this being the case in both the pollen and embryo-sac mother-cells, and my present studies have only confirmed this statement.

Grégoire claims that in *Lilium candidum* and *L. speciosum* the chromosomes become isolated and independent before the nuclear membrane has disappeared. In some cases in *Lilium candidum* and *Fritillaria persica* it seems that the chromosomes are isolated before the nuclear membrane disappears, but this is rarely the case in *L. Martagon.* Moreover, no special importance has been attributed to the fact that the spindle fibers enter the nucleus in some cases before the individual chromosomes are completely isolated. It is not necessary, however, to demonstrate the identity of the chromosomes throughout the second mitosis to show conclusively that two longitudinal divisions of the chromatin occur during the first mitosis.

After the nuclear membrane has disappeared and the multipolar spindle complex is laid down, or in the process of formation, the chromosomes are, as a rule, so closely entangled, kinked, and twisted that it is impossible to trace them save in exceptional cases. For this reason it is extremely difficult, if not impossible, to determine beyond all doubt the manner in which they are formed from the spirem. *Fig. 12* represents a section of a daughter nucleus in the multipolar stage of the spindle. In this case the spirem is more loosely arranged, and many of the loops and turns may be traced with greater accuracy than in the vast majority of instances. From this and *figs. 13*, *14*, and *15*, it is evident that the two segments of each chromosome in the nuclear plate represent probably the two parallel limbs of the loops observed at an earlier stage, which have become more or less closely applied to and sometimes twisted upon each other. The fact that the turns of the spirem in the daughter nucleus are not all regular and uniform accounts for the twisted and entangled condition of the chromosomes during the formation of the spindle. In the mature spindle (*figs. 14, 15*) the chromosomes are arranged both radially and tangentially. The two elements of each chromosome may lie parallel with each other, or they may remain almost entirely separate, being in contact only at the ends that are attached to the spindle fibers (*fig. 14*). This seems to be more frequently the case in *Lilium candidum* and Fritillaria. In the latter arrangement both elements may lie upon the same side or upon opposite sides of the equatorial plane. The chromosomes are fastened to the spindle fibers at or near the ends, rarely near the middle. When they are fastened near the ends, these are generally bent somewhat so that the retreating segments appear in the form of rods which are slightly hooked at the ends turned toward the poles (*fig. 17*).

Strasburger (1900), Guignard, ('99), and Grégoire ('99) claim that the two segments of each chromosome in the second division correspond exactly to the pairs of granddaughter segments which form the V's or U's of the first mitosis, and that they are fastened to the spindle at the places of bending or at the angles of the V's as in the first mitosis. Theoretically there may be little objection to this statement, as the matter in question may be a detail of secondary importance, but it seems that the observed facts will not admit of its general application in Lilium. *Figs. 13, 14*, and *15* show clearly that the free ends of the loops or V's are as likely to be attached to the spindle. Furthermore, we cannot say with certainty that the chromosomes of the second mitosis are identical with the pairs of granddaughter elements of the first division, for it does not seem impossible that the spirem may segment in such a manner that the segments of each chromosome of the second division may be derived from different pairs of granddaughter elements.

This may be brought about by the spirem segmenting at the apex of the V's rather than at the points corresponding to the free ends of the elements of each V, assuming that each long loop of the spirem represents a V. Under such circumstances, if all the granddaughter elements composing the spirem were so oriented in the preceding anaphase as to form V's, then all of the chromosomes of the second division would be made up of elements from different pairs of sister segments. But on the other hand, should the spirem segment in some places at the points corresponding to the angles of the V's, and at others which represent the points of contact of the free ends of the V-shaped chromosome, then some of the chromosomes of the second division would be composed of sister segments while others would not. If either of the last named possibilities be true, it might very easily happen that sister segments would go to the same granddaughter nucleus, a condition that might furnish a probable basis for a greater variation. Even though the latter supposition be true — that some or all of the chromosomes are not sister segments — it is possible that the results would be the same, for the spindle, or whatever part of the cell that has to do with the distribution of the chromosomes, may be able to prevent any such mixing by distributing to the granddaughter nuclei those chromatin elements which would unavoidably go to each if every chromosome were identical with the pairs of sister segments of the preceding division.

But since the chromosomes lose their identity in the daughter nucleus, neither of the foregoing suppositions can be objectively demonstrated. This is not possible, as yet, even in those cases in which the spirem is very regular or in plants with fewer chromosomes, and the possibility is still farther removed in those cases of more frequent occurrence in which the spirem is very irregular.

In the foregoing statements the writer does not intend to convey the idea that he rejects the older view, but the doctrine is advanced largely as a probability which seems to have some basis in fact. The older view, that the chromosomes of the nuclear plate of the second mitosis are identical with the pairs of granddaughter segments of the first division, is the simpler hypothesis, involving fewer complications, and for that reason it may be more readily accepted. Its truth, however, can be no more definitely demonstrated than that which I have suggested as a possibility, for there is no known angiosperm, so far as the writer is aware, in which the chromosomes of the first division do not lose their identity in the daughter nucleus, and we do not know with absolute certainty whether the daughter spirem segments in such a manner that the resulting pairs of segments are identical with the pairs of granddaughter segments of the first division. In those cases to be mentioned in a later paragraph, in which the daughter nucleus closely approaches or passes into the resting stage, it is readily seen how much more difficult the problem is.

A glance at those stages of the process represented in *figs. 12, 13, 14*, and *15* will give some idea of how the long and entangled chromatin segments are gradually brought to a more regular arrangement in the nuclear plate, although in species of Lilium with long chromosomes the arrangement, as a rule, is not very regular. The twisted and contorted form of the chromosomes seems to be due chiefly to the irregularity of the spirem.

During the transformation of the multipolar into the bipolar spindle, the entangled collection of chromosomes seems to be gradually pulled, pushed, and untangled into the more regular arrangement of the equatorial region, and there can be little doubt that the spindle fibers are primarily active in bringing each pair of chromosomes into its proper place.

As already stated, the segments of the chromosomes in the nuclear plate lie generally side by side and more or less twisted about each other. Sometimes the free ends of the segments diverge widely, those which are fastened to the spindle fibers being in contact or even separated a little. This phenomenon has been interpreted by some observers as metakinesis, but such a condition is sometimes met with before the spindle is mature. The spindle fibers have an orientation similar to that of the first mitosis.

As the segments separate during metakinesis, the nuclear plate presents a complicated picture (*fig. 16*). This phenomenon is due to the twisted condition of the chromosomes previously mentioned. On their way to the poles the segments may straighten out somewhat. Each is then usually a long and frequently undulating or bent rod, that is generally hooked at the end to which the spindle fibers are attached (*figs, 17, 18*). Sometimes the chromosomes are attached near the middle, in which case the retreating segments will be in the form of a V or a U.

The formation of the granddaughter nuclei presents nothing which demands a special mention.

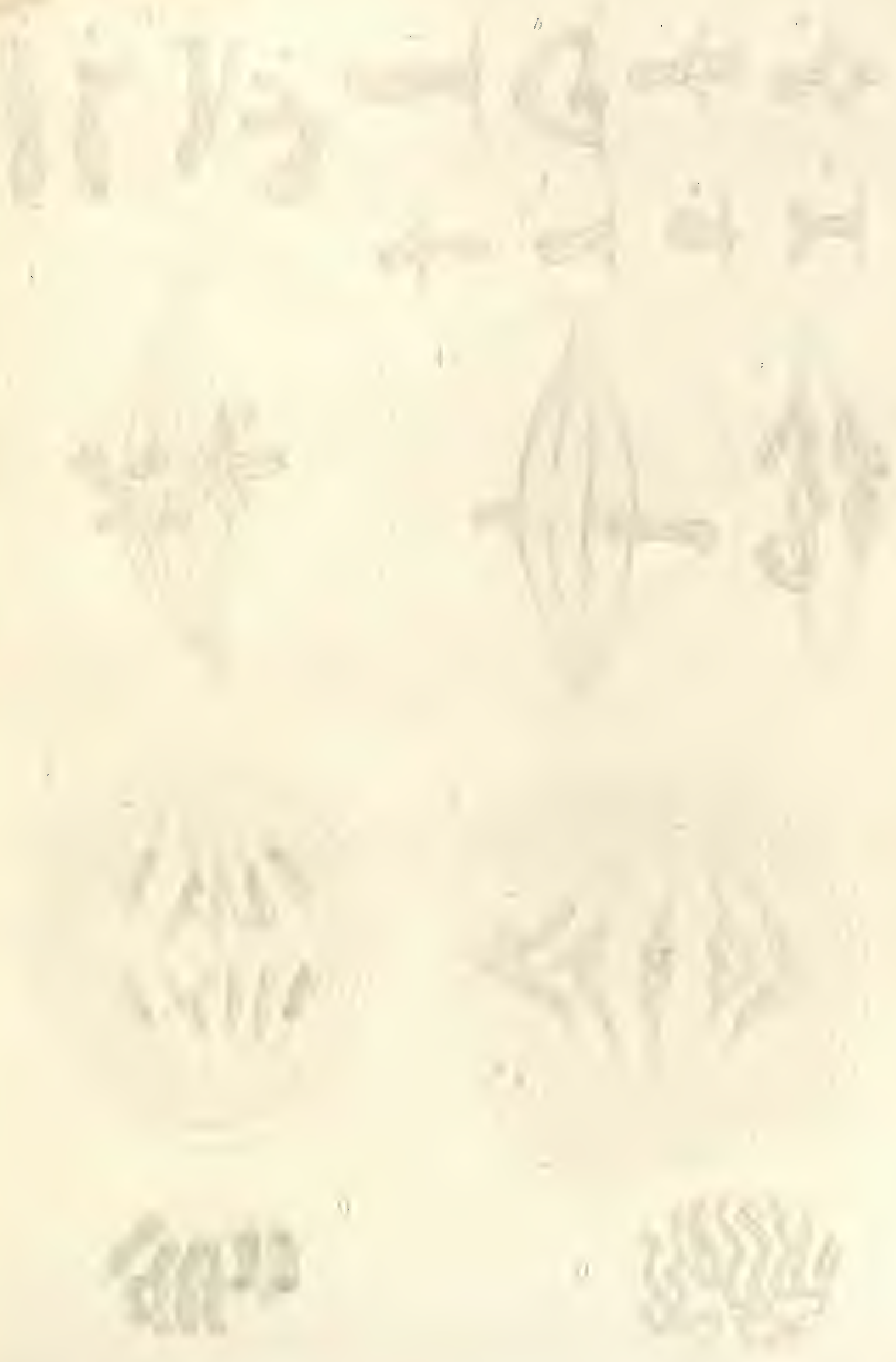
Confining himself to the study of the chromosomes in Lilium alone, the investigator would undoubtedly hesitate long before concluding in favor of the double longitudinal splitting of the chromosomes during the first mitosis, because of the variety existing in the form of the chromosomes and their orientation upon the spindle, the difficulty with which the double nature of the V-shaped elements which owe their form to a bending is generally recognized, and because of the extremely complicated character of the chromatin spirem during certain important stages of the second mitosis. The phenomena presented in *Podophyllum peltatum* and *Tradescantia virginica* leave no doubt whatever as to the correctness of this view.

The development of the chromosomes during the prophase of the first division in Podophyllum, as well as other important detail of karyokinesis, have already been fully described in my earlier paper (Mottier, '97), so that only enough of the process will be given here to bring out clearly the behavior of the chromosomes.

Soon after the segmentation of the spirem into chromosomes the daughter segments tend to become separated except at one or both ends, or they may adhere only near the middle and both ends diverge, as the daughter segments are usually somewhat curved. They may also remain in contact for their entire length, but this is less frequently the case. When the chromosomes are arranged in the nuclear plate they lie, as a rule, tangentially upon the spindle. The daughter segments are more frequently observed adhering at one end only, as in *fig. 20*, but, as in Lilium, should the segments adhere at both ends, the ring-shaped chromosome is the result (*fig. 19*). It not infrequently happens that both forms of chromosomes are seen in the same nuclear figure. *Figs. 19* and *20* show the manner in which these chromosomes are fastened to the spindle fibers. In those cases in which the daughter segments adhere only at one end, the ends in contact are so closely applied as to give the appearance of a lump or swollen place. This is especially true when the ends of the curved segments are turned directly toward or away from the observer. In case the daughter segments are in contact for their entire length the chromosomes may be fastened to the spindle at one end and arranged radially upon it; but, as a rule, the point of attachment is at the place of bending, whether that be near one end or at the middle of each segment. The X-, Y-, and U-shaped chromosomes, although of less frequent occurrence in Podophyllum, are formed in the same manner as described for Lilium.

During the metaphase, or immediately following it, each daughter chromosome is seen to be double or composed of two similar granddaughter segments, the result of the second longitudinal splitting (*figs. 22, 23*). The shape of the pairs of granddaughter segments will, of course, depend upon that of the daughter chromosome. In *fig. 21*, *a*, it is evident that this chromosome before metakinesis was similar to those in *fig. 20*. In *fig. 21*, *b*, the daughter segments may have been in contact throughout and the chromosomes fastened to the spindle at the end. The retreating pairs of segments in this case may present the familiar V's. The chromosome to the right in *fig. 22* was either in the form of a ring or a U when in the nuclear plate. This condition was observed at the time of my earlier study upon Podophyllum, but such conditions were interpreted as two similar but different chromosomes lying close together, one beneath the other.

The double nature of the daughter chromosomes can be clearly distinguished until they reach the poles. Having arrived at the poles, they generally become closely crowded together so that the individuals are difficult to distinguish. It can be seen, however, that the segments of each pair tend to separate, and there was nothing observed which might lead one to conclude with any certainty that a double spirem is formed. The granddaughter segments in forming the spirem tend to reticulate somewhat so that they become irregular in shape and their exact identity is lost. Those observers who assert without reserve that the identity of the chromosomes can be followed at all times from one division to the other, certainly leave this fact and other steps of the process out of consideration.



MOTTIER on CHROMOSOMES

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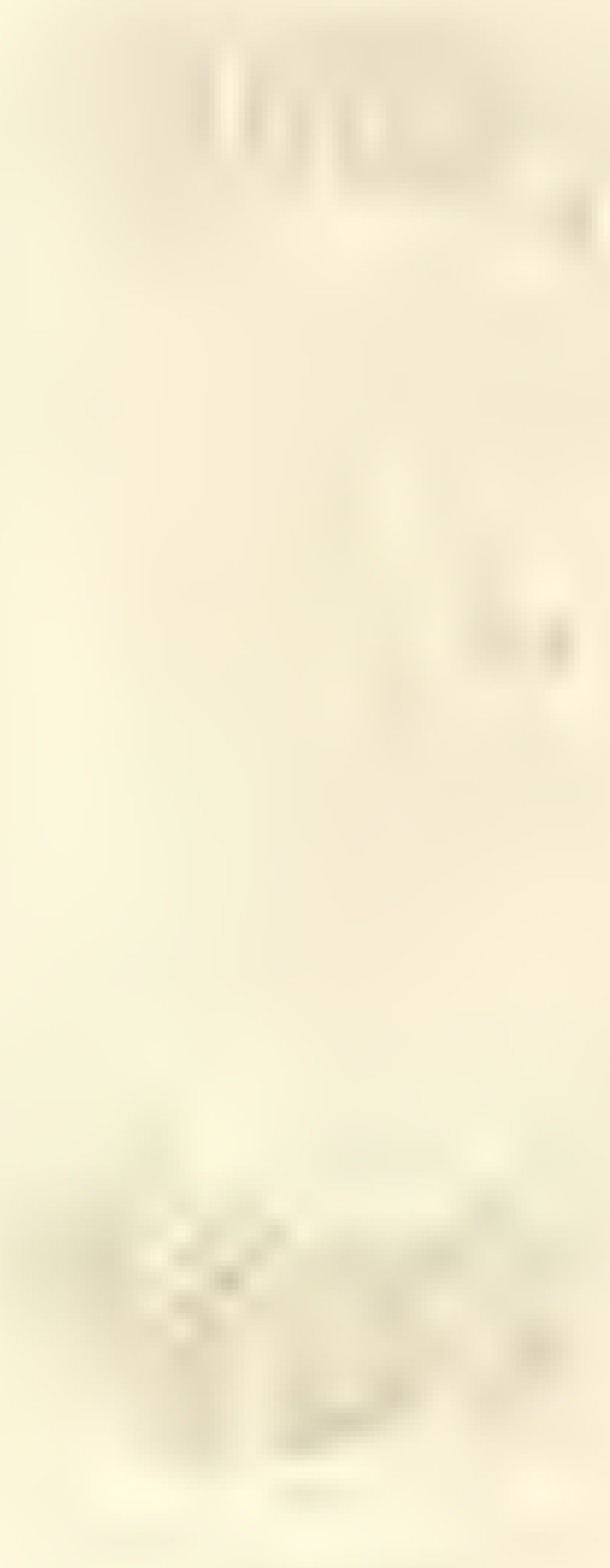

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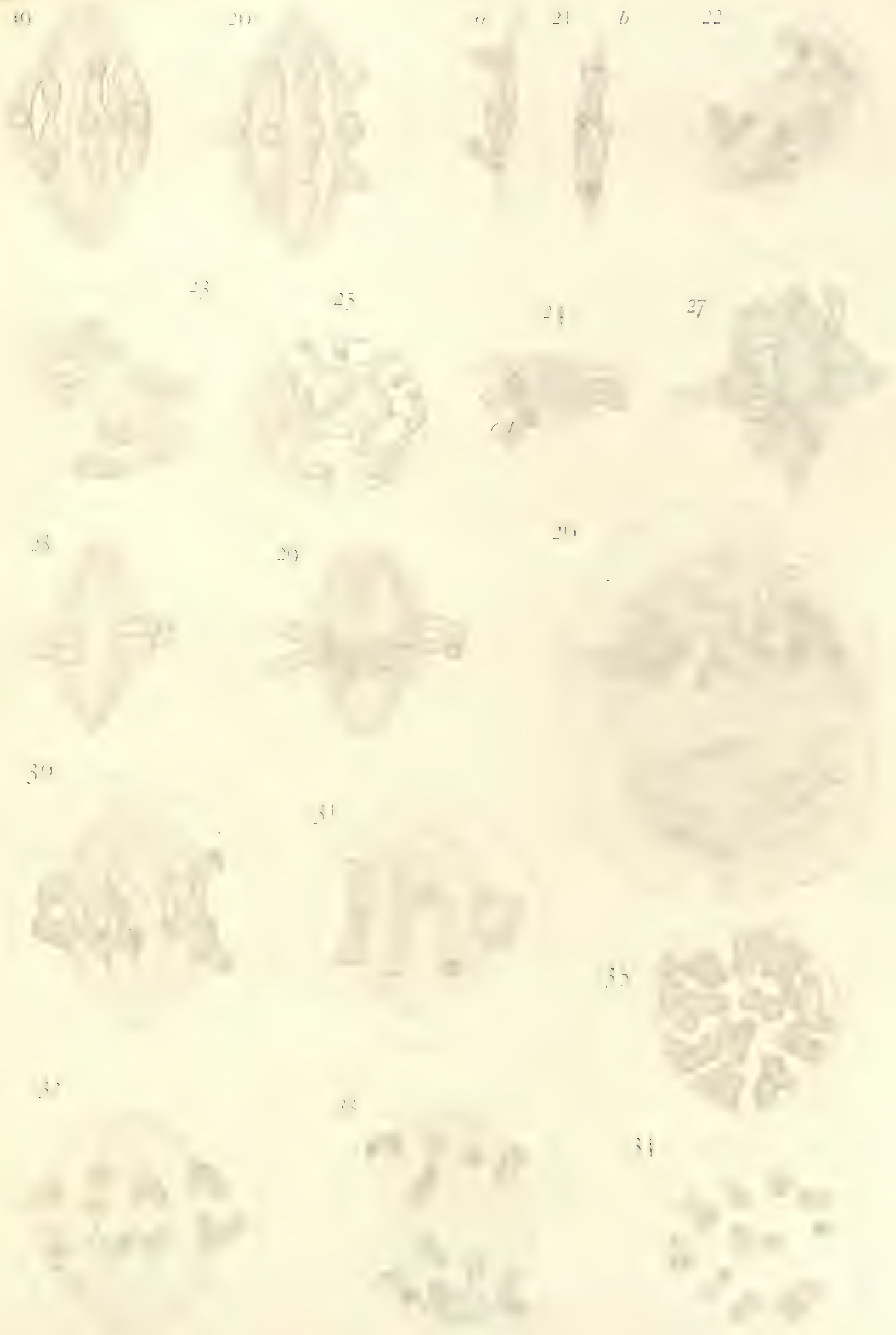
MOTTIER on CHROMOSOMES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MOTTIER on CHROMOSOMES

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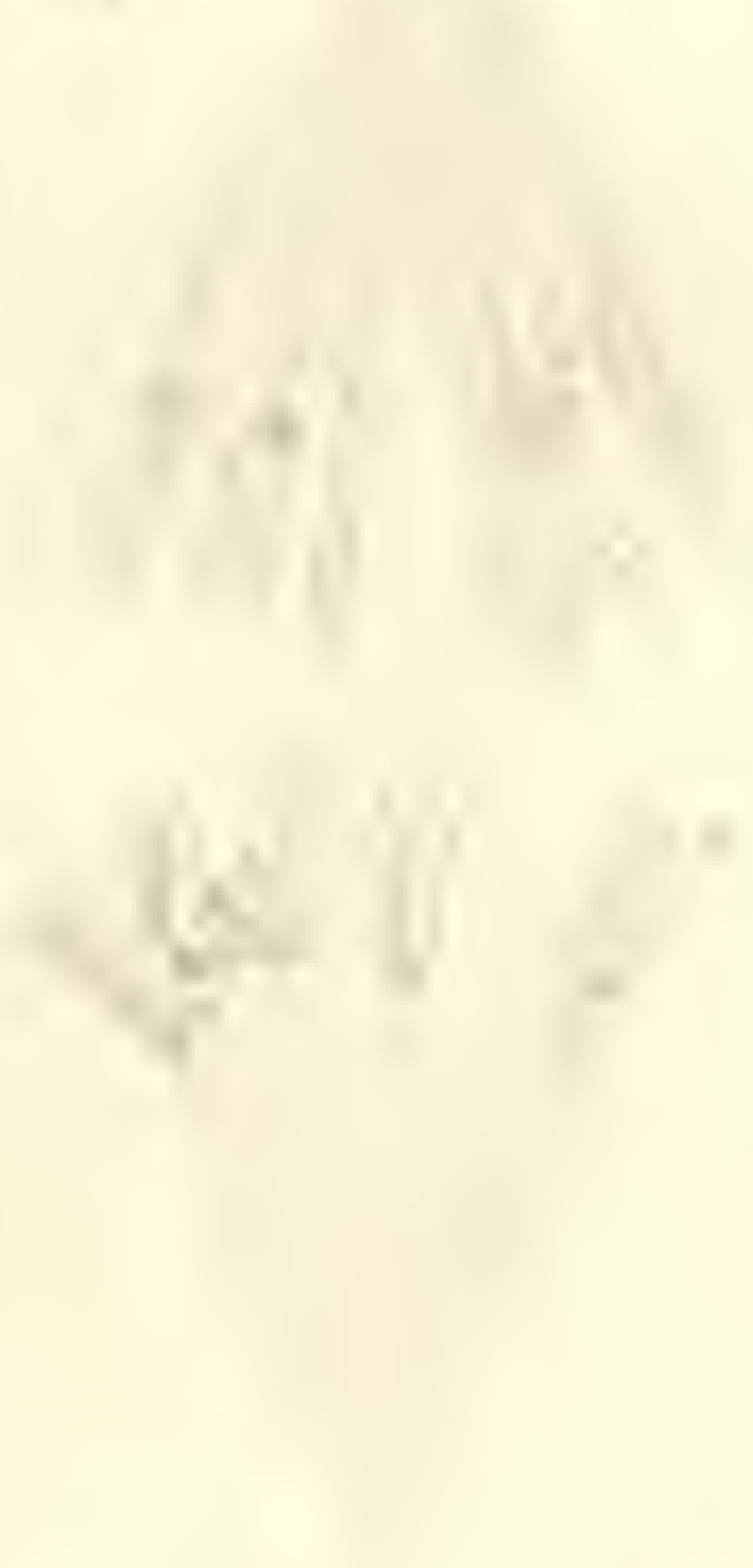

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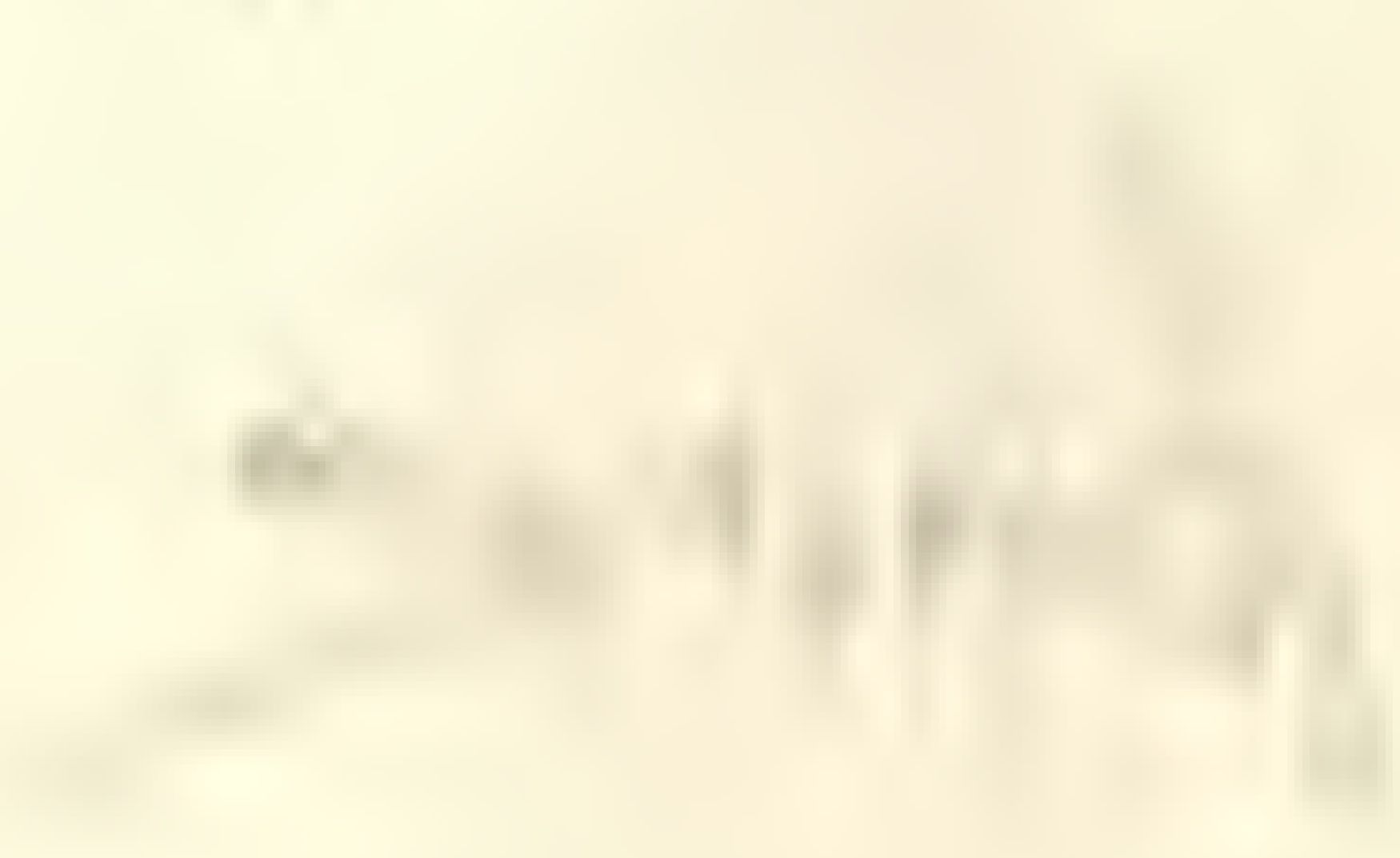

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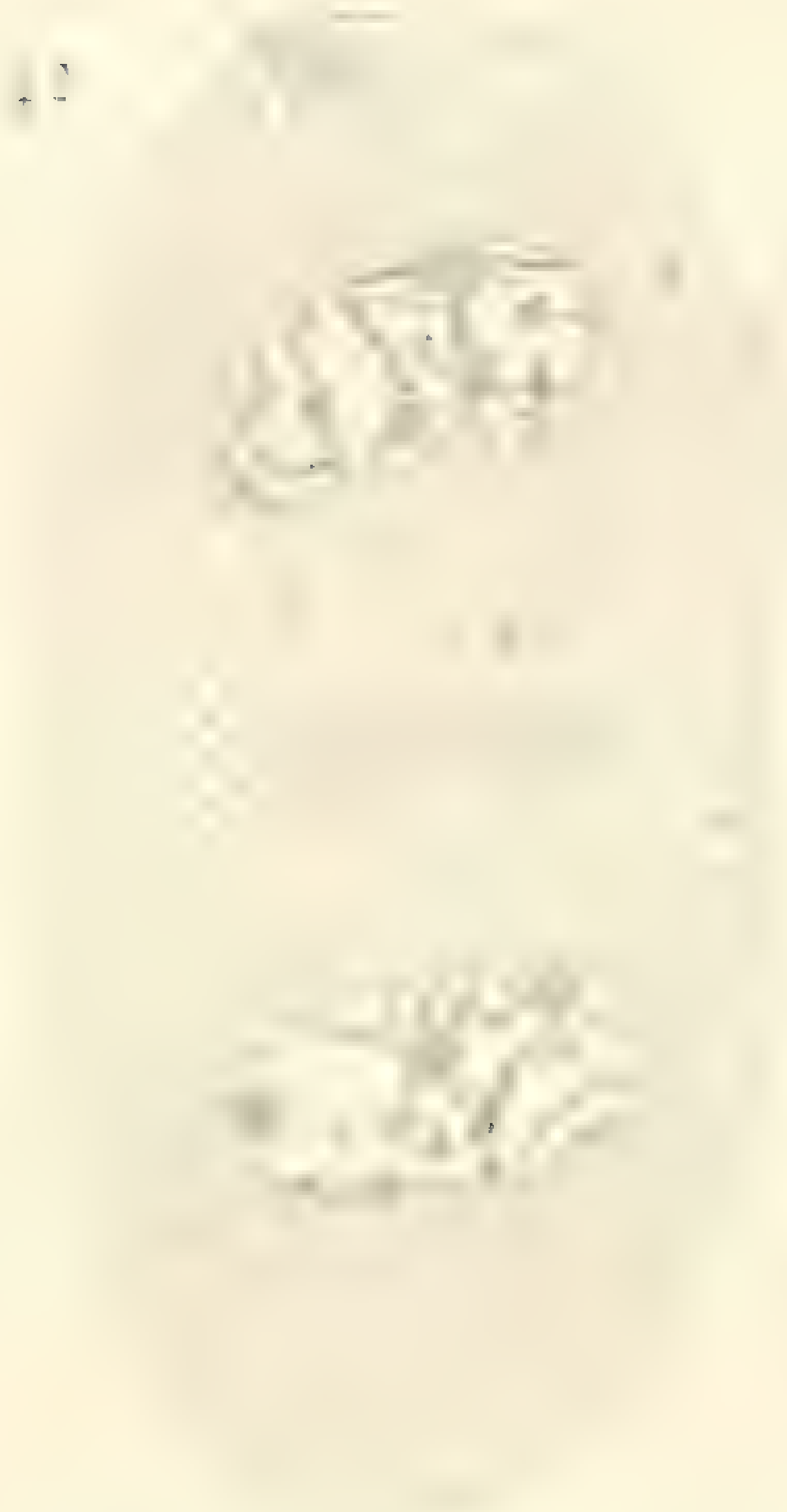

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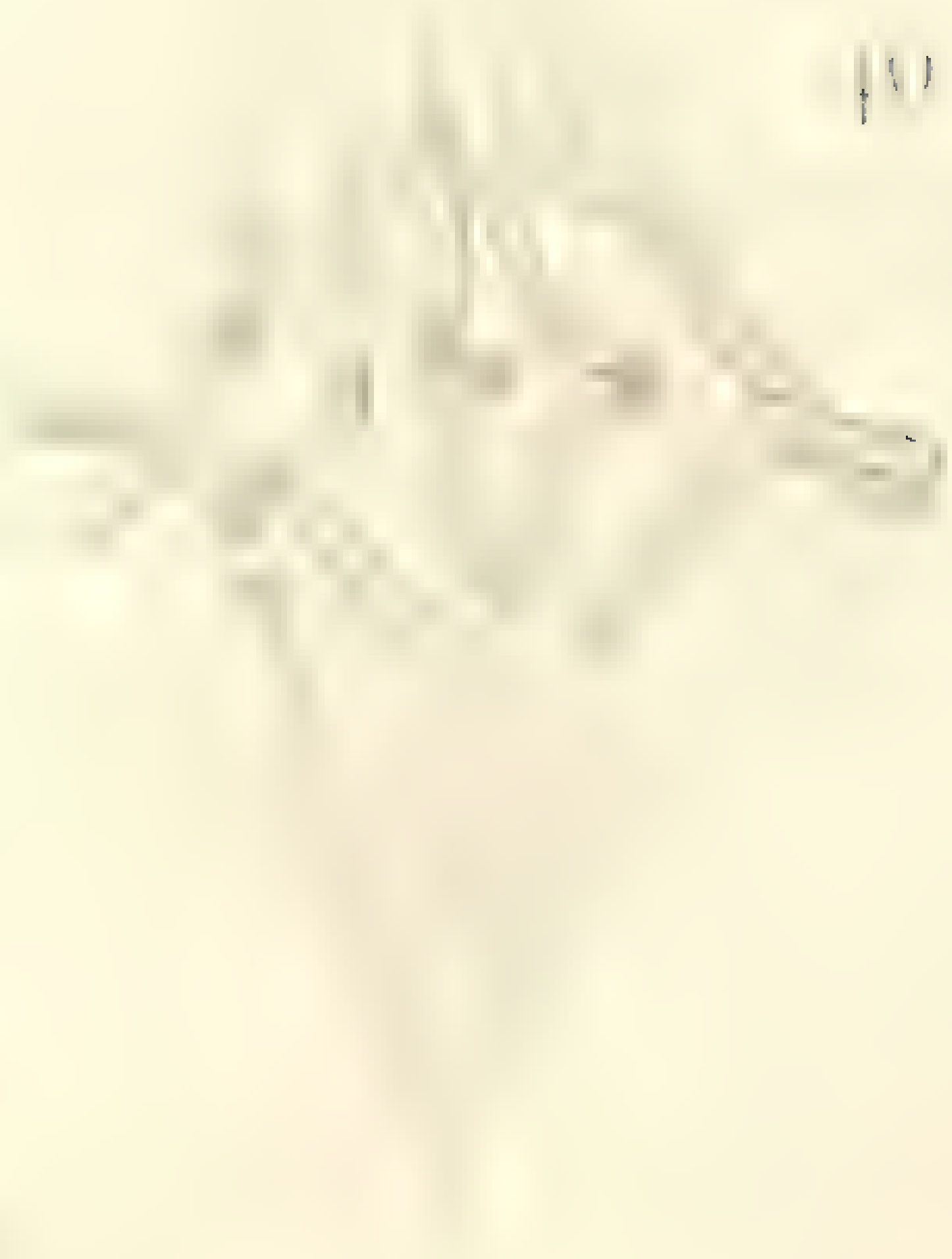

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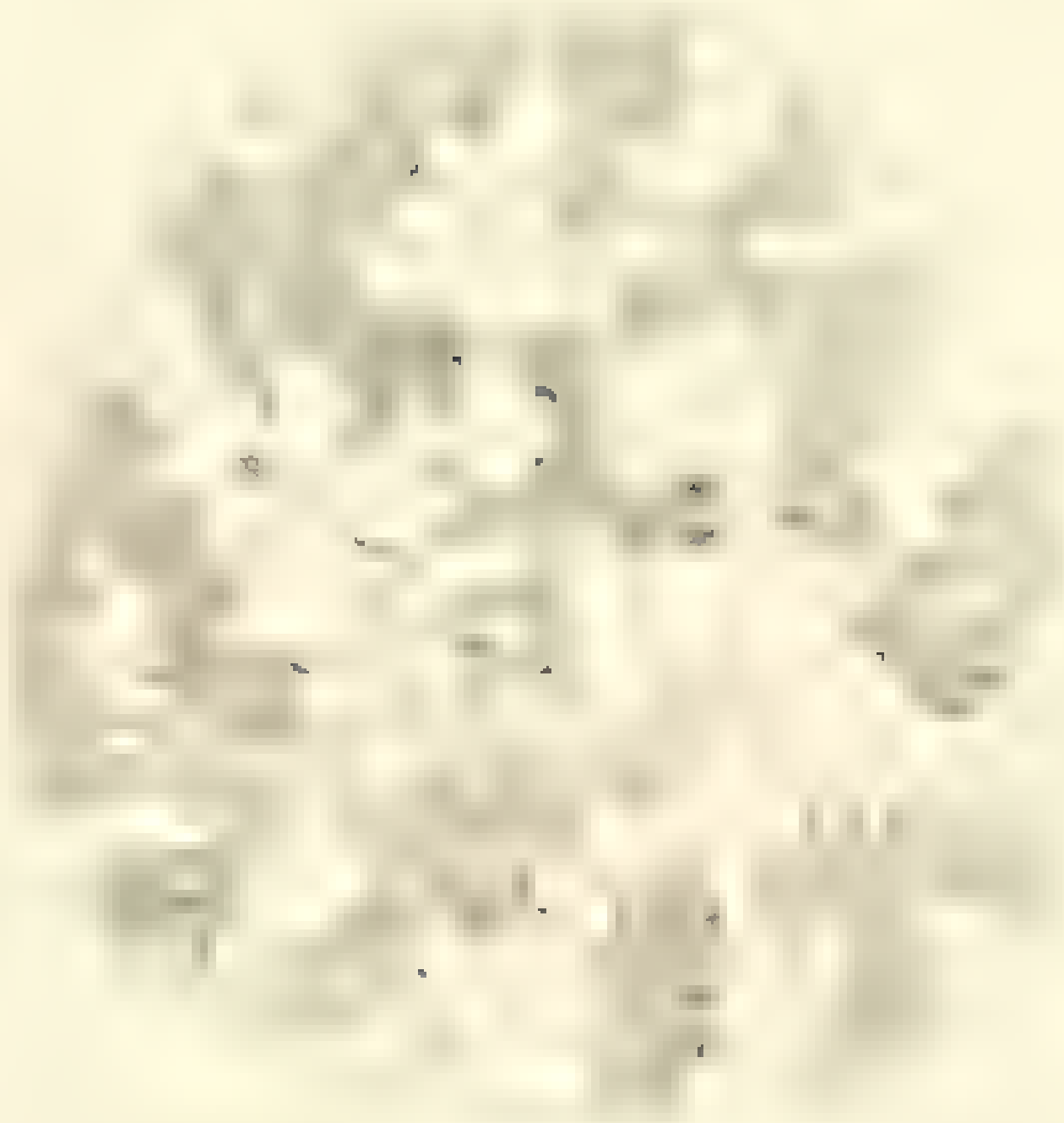

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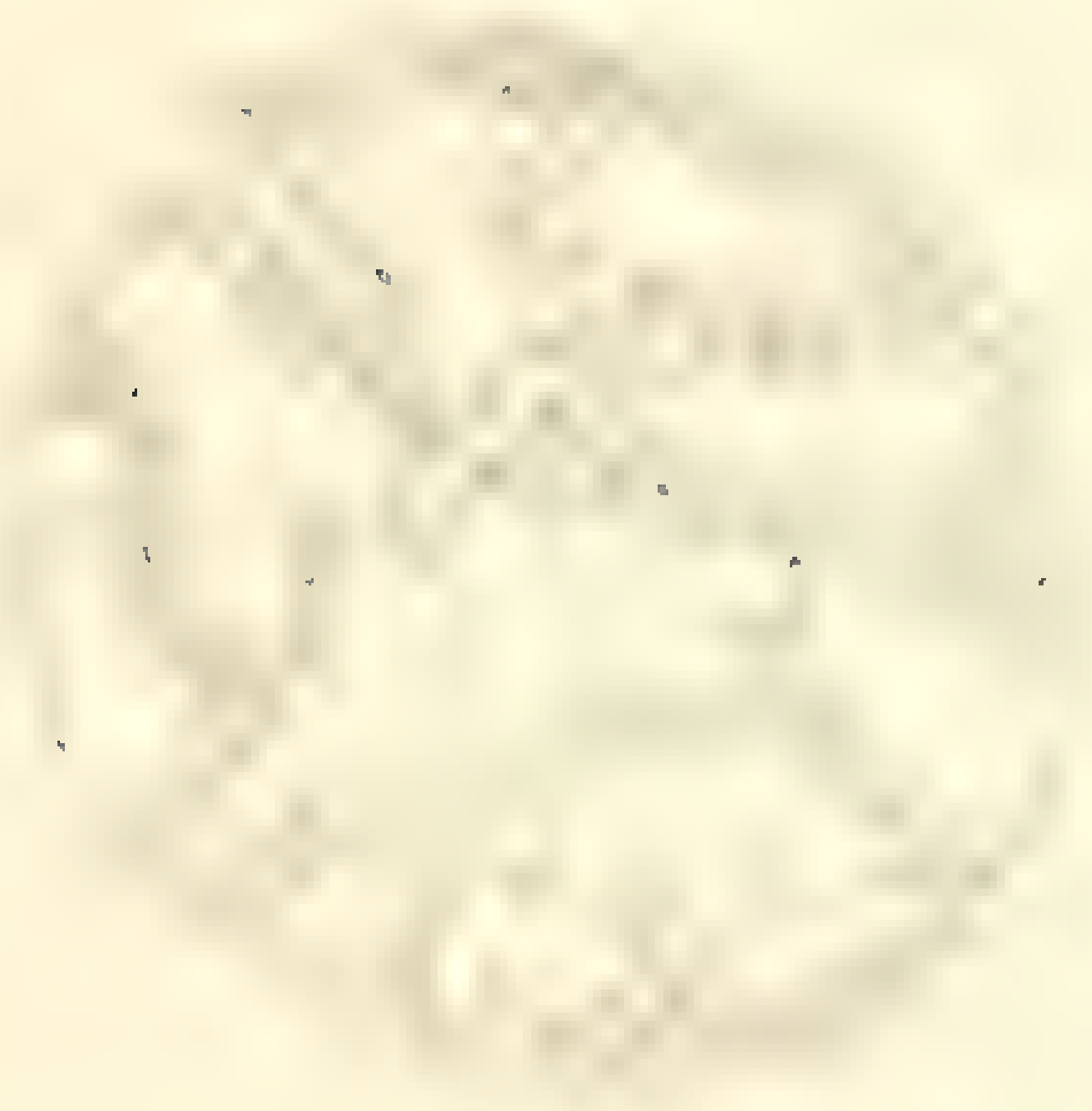

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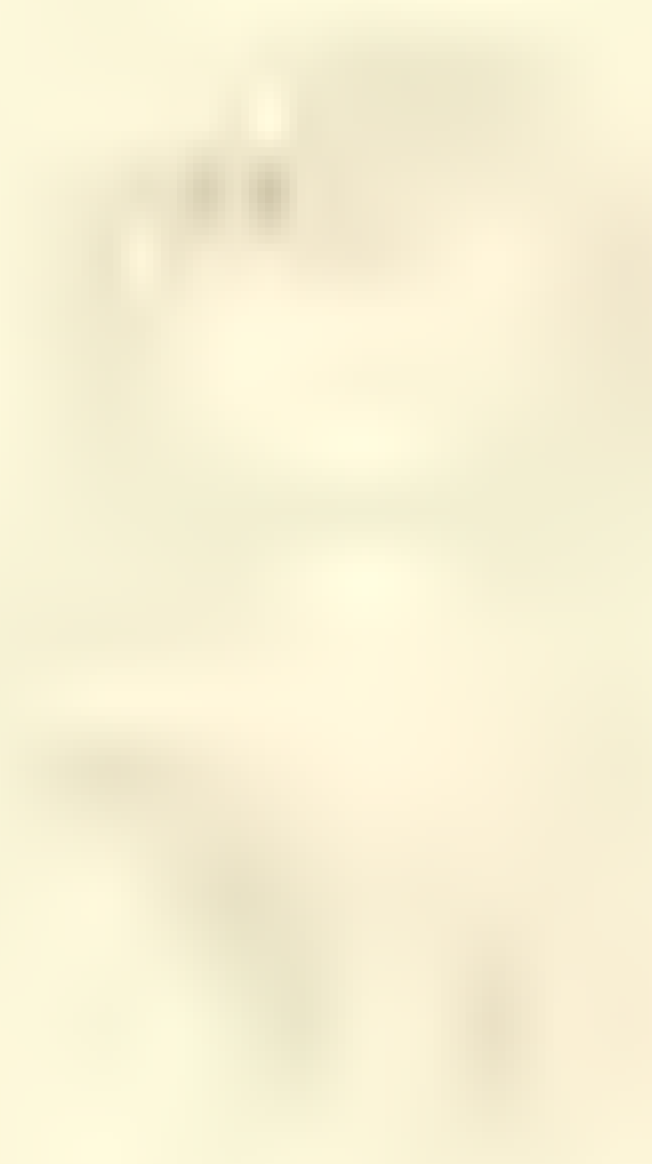

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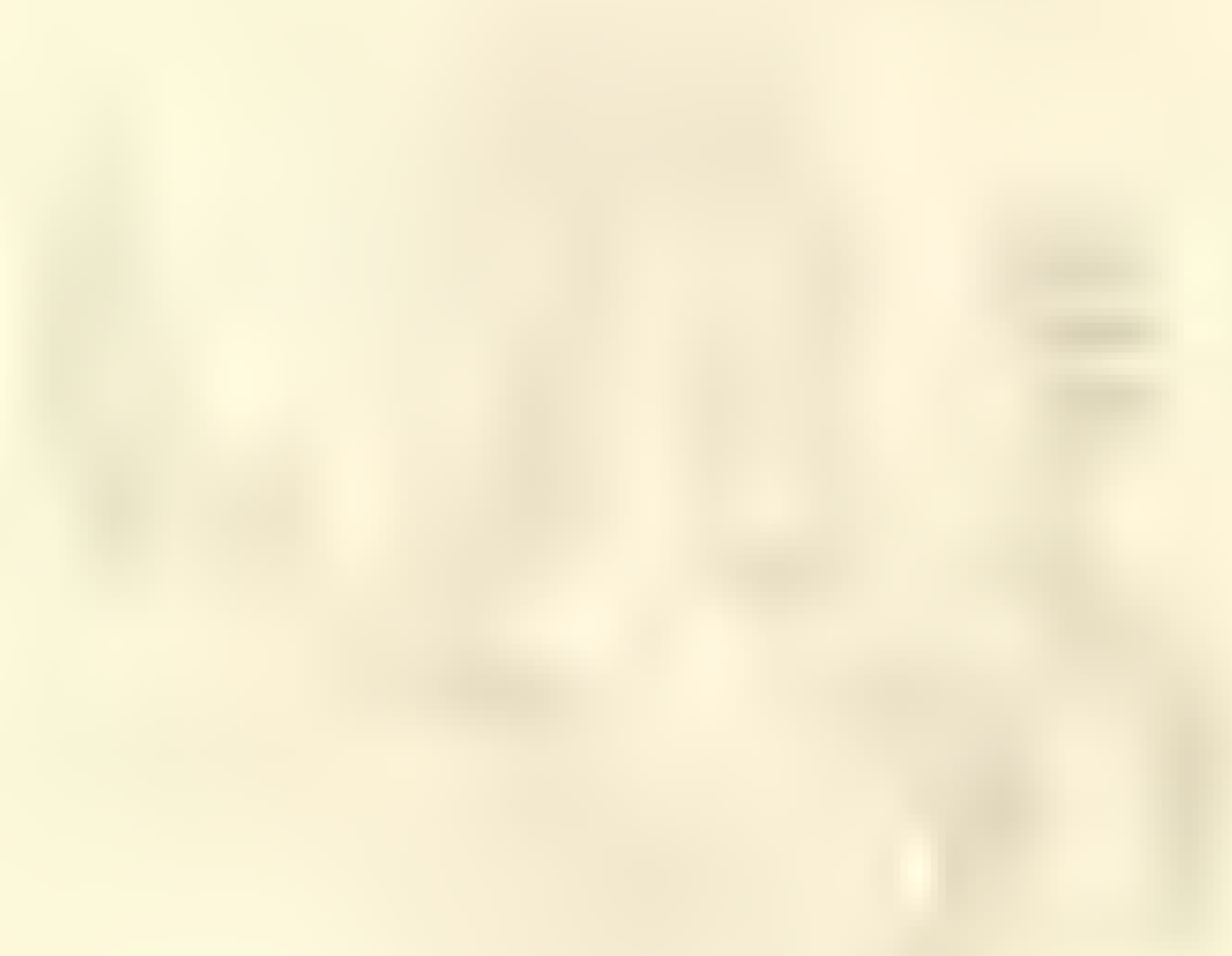

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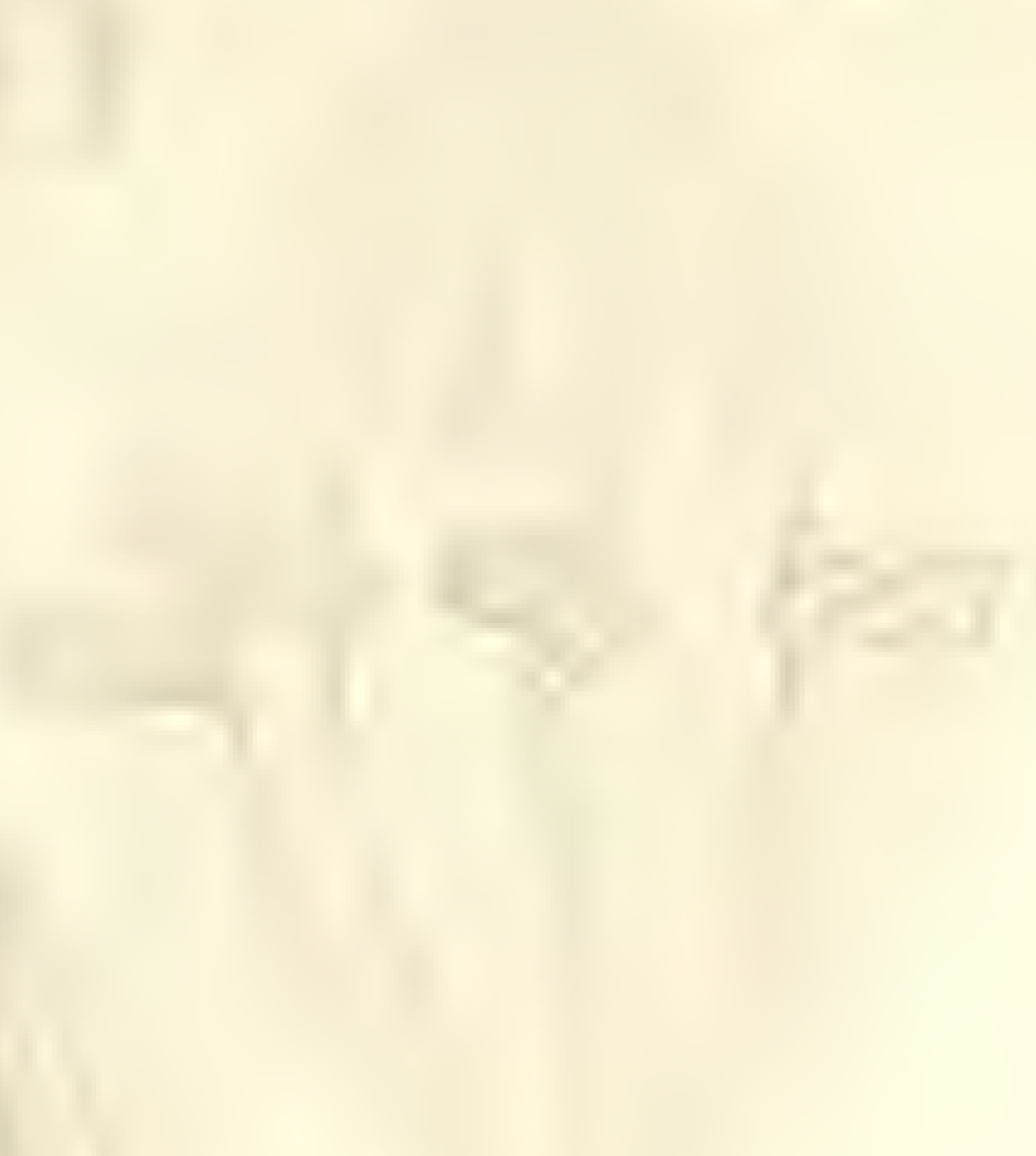

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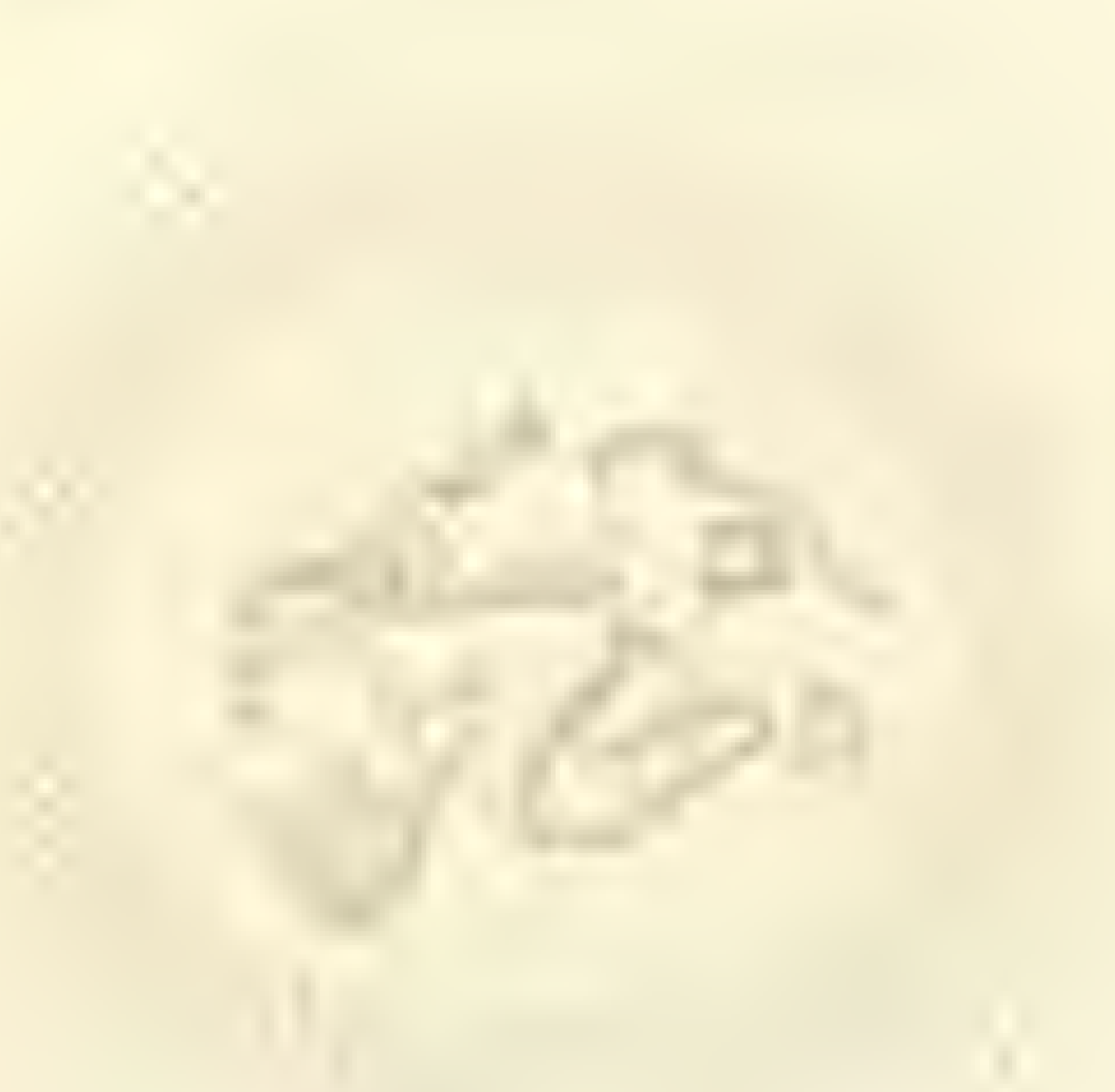

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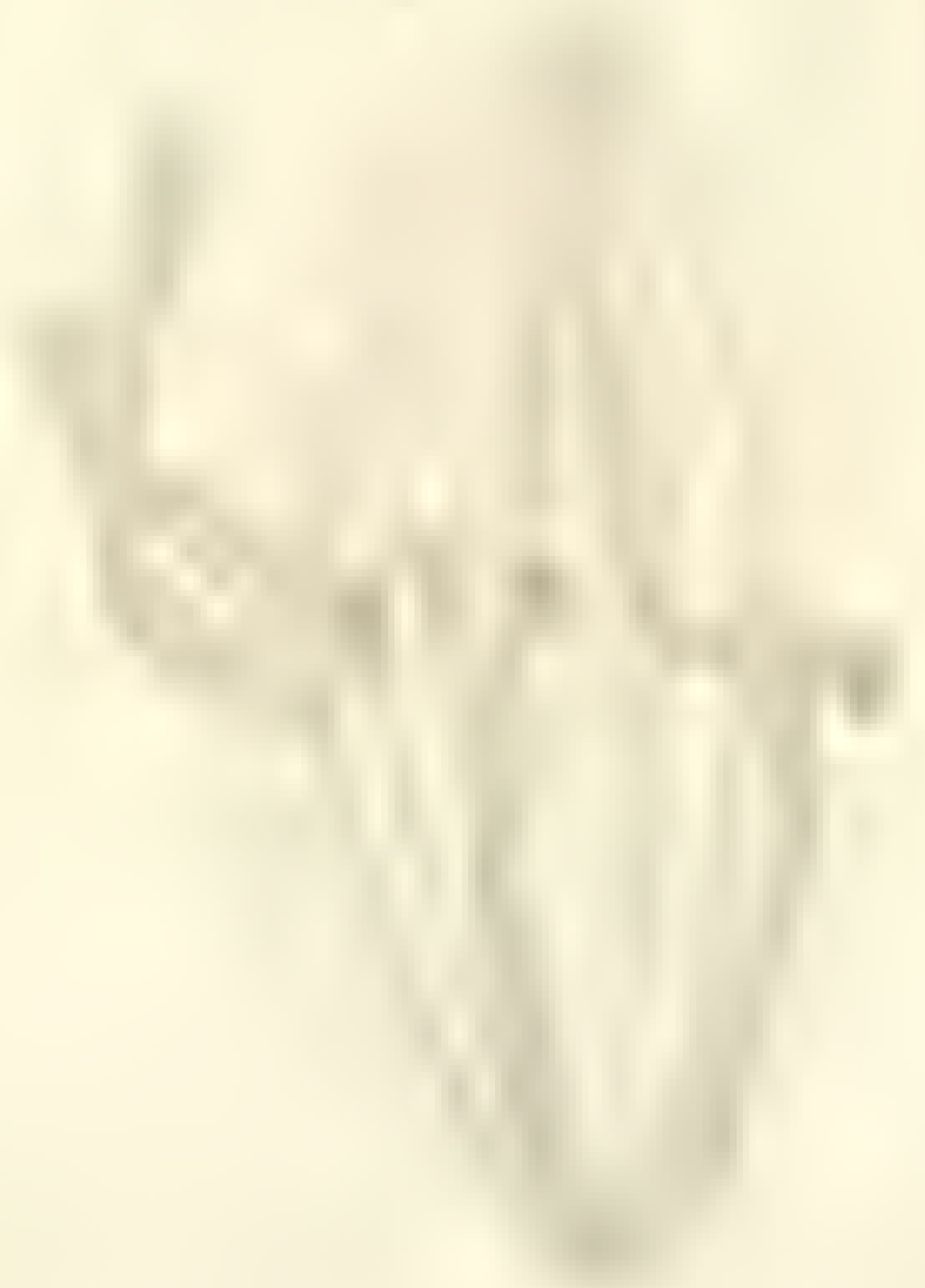

MOTTIER on CHROMOSOMES

In a short time, a more regular spirem is formed in which parallel or adjacent portions are frequently connected by fine threads. As I have already shown, the spindle of the second division arises as a multipolar structure (*fig. 26*). During the formation of the spindle, the chromatin spirem segments into the chromosomes. The segments are collected together within the complex of spindle fibers so that the manner of segmentation can not be determined with certainty. The same would be true if the spirem segments before the nuclear membrane had disappeared, and it is a matter of little importance whether the spirem segments before or after the disappearance of the nuclear membrane. In many cases it seems that the spirem breaks up into pieces equal in length to the two segments of the chromosomes, but this does not always appear to be true (*fig. 26*). However, during the transformation of the multipolar complex of fibers into the bipolar spindle, the chromosomes are gradually arranged more regularly into the nuclear plate (*figs. 27, 28*). Each chromosome consists now of two similar segments which may or may not be closely applied to each other. Instances have been observed in which the two segments of a chromosome were of a slightly different length. The chromosomes are probably identical with the pairs of granddaughter segments of the first division, but here, as in Lilium, we do not know definitely whether the two segments of each chromosome are sisters. The chromosomes are mostly in the form of rather thick rods more or less curved. They are fastened to the spindle fibers near the ends or at the place of bending. The retreating segments, therefore, may be nearly straight, hooked, V- or U-shaped.

Among monocotyledonous plants, apart from the lilies, few perhaps are more suitable to demonstrate the fact of a double longitudinal splitting of the chromosomes during the first mitosis in the pollen mother-cells than *Tradescantia virginica.*

Between the time of the segmentation of the chromatin thread into chromosomes and the development of the spindle, the chromosomes contract greatly, becoming shorter and thicker. The daughter segments tend to separate except at one or both ends. In case they adhere at both ends, a ring or ring-like chromosome results. At the time of or even before the formation of the spindle, the daughter segments contract to such an extent that each may be in the form of a short, thick crescent. Each ring-like chromosome will therefore consist of two crescents whose ends adhere (*fig. 30*). It not infrequently happens that the daughter segments contract in such a manner that closed rings are formed. If the daughter segments remain adhering at one end, each chromosome in the nuclear plate is seen to consist of two thick pieces in the form of either a short crescent, a broad U, or only slightly bent at one or both ends (*fig. 31*, on the left). Under these circumstances the whole chromosome is relatively long, reaching almost from pole to pole.

As a rule the chromosomes are oriented tangentially upon the spindle, the fibers being fastened at the middle of each segment or near one end. It is interesting to note that the place to which the fibers are attached is almost always in the form of a small protuberance, giving the impression that a pull is exerted by the spindle fibers, In *fig. 30* is shown the singular phenomenon of two chromosomes fastened together, a fact which is of course without any special significance.

No indication of a second longitudinal splitting is seen in Tradescantia when the chromosomes are in the nuclear plate, and, so far as could be determined with certainty, not even during metakinesis, although it may occur here as early as in Lilium (*figs. 30, 32*); but by the time the daughter chromosomes have traversed one-half the distance toward the poles, it can be usually seen that each consists of a pair of granddaughter segments, arising from the second longitudinal splitting (*fig. 33*).

Having arrived at the poles, the pairs of granddaughter segments become somewhat crowded together, and shortly the nuclear membrane is laid down (*fig. 35*). The segments, or some of them at least, now separate slightly; but as they begin to reticulate, becoming lumpy and very irregular, their identity is soon lost. The process of reticulation continues, and at a little later stage the lumpy chromatin masses which are connected by numerous fine threads present the appearance of *fig. 36*. As in many other plants, there is not an even and uniform spirem formed at once from the segments of the daughter chromosomes. The reticulation continues, at least in many cases observed, until a structure is reached that is certainly very near that of a resting nucleus. *Fig. 37* represents a nucleus seen from the pole. If the same nucleus were observed from the side, at this or even a little earlier stage, its chromatin would present the appearance of a rather thick and irregular spirem.

There are phenomena in Tradescantia which would suggest that the daughter spirem or parts of it are formed double, but all the evidence taken together seems to indicate that only a single spirem is the result. Daughter nuclei were observed in which certain parts of the spirem, or chromatin thread, seemed to be double, while other parts showed nothing of a double character. The chromatin of the daughter nucleus does not form the regular and uniform spirem to be observed in other monocotyledonous species and in Podophyllum, and for this reason the differentiation of the chromosomes is followed with greater uncertainty. With the approach of the second mitosis, the chromosomes are differentiated and lie distributed in the nuclear cavity before the disappearance of the nuclear membrane. They are often very irregular in shape and connected by delicate linin threads. Even when arranged in the nuclear plate, they present an irregular, lumpy, and twisted form. In those cases in which the chromosomes are most regular, each is seen to consist of a pair of rod-shaped segments which are either straight with only a slight bend at one end, or more or less undulating and twisted (*fig. 39*). As in Lilium, some of the chromosomes are oriented radially and some tangentially upon the spindle.

It may be that the two segments composing each chromosome are sisters, and that the chromosomes are identical with the pairs of granddaughter segments of the first division, but the possibility of an objective demonstration of this supposition seems out of the question.

The process of the second karyokinesis in the pollen mother-cells of other plants seems to suggest strongly that the division of the daughter nuclei has some other purpose than merely the distribution of an equal number of chromosomes to the four granddaughter nuclei.

In 1898, the writer showed clearly the striking similarity between the first two mitoses in the micro- and macrospore mother-cells of *Helleborus foetidus* and *Lilium Martagon*, and concluded upon that evidence that the pollen and embryo-sac mother-cells were homologous. The work of recent observers, especially Juel (1900) and Schniewind-Thies (1901), who have confined their attention primarily to this phase of the problem, has only confirmed this view.

Since the chromosomes in the pollen mother-cell undergo a double longitudinal division during the first or heterotypic mitosis, the same would seem certain also in the embryo-sac mother-cell, and it was for this reason that a reinvestigation of the problem in *Lilium Martagon* was undertaken.

As was expected, the first and second mitoses in the embryo-sac were found to be essentially like those in the pollen mother-cell. These divisions will be described somewhat in detail in order to show what the embryo-sac contributes toward the solution of this and other problems suggested in the preceding pages.

As is well known, the mother-cell of the embryo-sac of Lilium becomes the macrospore and develops at once into the embryo-sac. The first nuclear division is heterotypic, the nucleus undergoing the same changes during the prophase as in the pollen mother-cell. The spindle arises as a multipolar structure, and the form and orientation of the chromosomes within the multipolar complex of fibers and upon the mature spindle present nothing requiring a special description.

Owing to the small number of macrospores in an ovary as compared with the number of microspore mother-cells in an anther, a much smaller number of karyokinetic figures will be observed in the former, yet in the course of an extended investigation, it seems exceedingly probable that about the same variety in the form of the chromosomes exists in the macro- as in the microspore mother-cell. As a rule, the daughter segments are twisted upon each other and fastened to the spindle fibers by the ends (*fig. 40*). Only in exceptional cases can any indication of the second longitudinal splitting be discerned before metakinesis. As soon as the daughter chromosomes separate, however, each is seen to consist of two similar granddaughter segments. The figures which these pairs of segments present will depend, of course, upon the orientation of the daughter chromosomes toward each other, their shape, and mode of attachment to the spindle fibers.

The retreating segments, therefore, may form V's, U's, or more or less contiguous rods, which may be undulating or abruptly bent, and, as is sometimes the case, hooked at the ends directed towards the poles (*fig. 41*).

Having reached the poles, the granddaughter segments do not, at least as far as my observations have extended, form immediately a regular spirem of a uniform thickness, but there is here a greater tendency on the part of the chromatin elements to become reticulated and pass into a structure closely approaching that of a resting nucleus. This was found to be true in all cases observed. As will be seen from *fig. 42*, the two daughter nuclei present a structure which is certainly very near that of a resting nucleus. Several nucleoli are present, and there is no regular, continuous spirem. Although the nuclear thread may be continuous, yet the chromatin is in the form of granules that are of a very variable size and unevenly distributed. Certain portions of the nuclear thread contain apparently a single row of small chromatin granules, as in an early prophase of karyokinesis; in other portions two rows of these granules are present, while still other parts are thicker and somewhat lumpy.

In the light of all the facts observed, nothing seems more certain than that in the daughter nuclei all identity of the chromosomes is lost from observation. While it is true that a greater pause intervenes or seems to exist between succeeding nuclear divisions than between the first and second mitoses, yet it does not follow that the second division takes place immediately after the first without a resting pause.

As regards the details of further karyokinetic activity in the embryo-sac, I am able to add little to my former observations. As already mentioned (Mottier, '98), the second mitosis bears certain striking resemblances to that in the pollen mother-cell. In all probability they are exactly the same. In the chromatin spirem no indication of a longitudinal splitting is to be seen. The nuclear membrane disappears as such, and the spindle fibers penetrate the nuclear cavity before the spirem is segmented into chromosomes (*fig. 43*). The complete segmentation seems to be effected later than in the pollen mother-cell. Within the multipolar complex of spindle fibers the partly segmented spirem, as in the pollen mother-cell, is generally greatly entangled and kinked. As the spindle matures, the arrangement of the chromosomes becomes more regular, but, as a rule, less so than in *fig. 44*. When the spindle has reached the typical bipolar stage, the chromosomes are oriented in the nuclear plate, some radially and some tangentially (*fig. 44*).

Each consists of two rather long and closely applied segments that may be twisted upon each other. It seems that the spirem may not be entirely segmented even when the typical bipolar stage of the spindle is reached (*fig. 44*), and as the apparently unsegmented portions are double nothing seems more reasonable than the conclusion that the double nature is due to the longitudinal splitting of the chromatin spirem, and it was upon this evidence that my conclusion of 1898 was based, namely, that the spirem of the daughter nucleus undergoes a longitudinal fission.

Since the second longitudinal fission takes place during the first mitosis, it is not difficult to understand, especially when one bears in mind the entangled or kinked condition of much of the spirem during the development of the spindle, and the fact that portions of it are very slender, appearing as if stretched by the fibers, how parallel portions of the spirem may be so brought in contact as to look like a longitudinal splitting had occurred. Further evidence in favor of the doctrine that the two segments of each chromosome are brought in contact side by side, is the fact that in both pollen and embryo-sac mother-cells one very frequently meets with chromosomes that do not consist of two rather straight and readily distinguishable segments, but rather short, thick, and lumpy chromosomes which show that the segments are kinked or twisted up into a short spiral or coil. It seems furthermore exceedingly probable that the longer and more uniform turns of the spirem will furnish the regular and straight chromosomes, whilst the less regular parts — for such exist in the majority of the daughter nuclei in question — give rise to the short, kinked, or knotted ones.

It may be mentioned in passing that every step in the development of the spindle seems to bear direct evidence in favor of the view that the arrangement of the chromosomes is accomplished by a pushing and pulling action of the spindle fibers.

Relative to the behavior of the chromatin, it may be stated finally that the possibility is not excluded that in some cases the spirem may be formed double, in part or entirely, but direct evidence of such a possibility was not observed save in the presence of two rows of chromatin granules in portions of the thread-work of the daughter nucleus.

The daughter nucleus in the lower end of the embryo-sac, which gives rise ultimately to the antipodal cells and the lower polar nucleus, behaves in division exactly as the upper, and the fact that this nucleus presents a larger number of chromosomes only adds more difficulties to the problem of the chromosomes.

In certain respects, the third karyokinesis in the embryo-sac of *Lilium Martagon* resembles the second. This is true as regards the development of the spindle whose fibers penetrate the nuclear cavity before the chromatin spirem is entirely segmented into the chromosomes (see Mottier, '98, *figs. 16, 17*). The behavior of the chromatin, however, is quite like that in ordinary and typical vegetative cells.

The first two mitoses in the spore mother-cells of higher plants, therefore, are heterotypic and homotypic respectively, these terms being used in the sense of Flemming. The chief distinguishing characteristic of the heterotypic nuclear division is the double longitudinal fission of the chromosomes. The shape of the chromosomes is without importance, since the form of the individual chromatin elements, which often varies in the same nucleus, is due to different causes. This division is further characterized in plants by a rather long period of growth during the prophase which results in a marked increase in the size of the nucleus and in the quantity of chromatin substance. In the higher plants, it is during this division that the reduced number of chromosomes appears.

In the homotypic division, the chromatin spirem or thread does not undergo a longitudinal fission. During the development of the spindle the granddaughter chromosomes are arranged in pairs in the nuclear plate by means of the spindle fibers. The segments of each pair often lie closely applied side by side in such a way as to suggest that the daughter spirem had split longitudinally. This arrangement of the segments with reference to each other does not always obtain, for they may frequently diverge, one lying tangentially upon one side of the equator and the other upon the other side. In the pollen mother-cell of Lilium and in certain other plants, the homotypic may follow the heterotypic division without the intervention of a complete resting stage, but even here there is a greater or less tendency for the daughter nucleus to pass into the structure of the resting condition. In all cases, however, the identity of the individual chromosomes is lost from observation in the daughter nucleus.

THE HOMOLOGY OF THE MICRO- AND MACROSPORE MOTHER-CELLS.

From the foregoing statements and in the light of the recent researches of Juel (1900) and Schniewind-Thies (1900), it seems that all cytological evidence indicates clearly and unmistakably that the pollen mother-cell and embryo-sac mother-cell are homologous.

The writer has already shown that the first nuclear division in the macrospore mother-cell of Helleborus is heterotypic, and the same is true for Podophyllum. In the development of the embryo-sac of Helleborus, which may be regarded as typical for dicotyledonous plants, as well as for many monocotyledonous species, the heterotypic and homotypic mitoses are each followed by cell-divisions, giving rise to four potential macrospores, homologous with the four granddaughter cells in the pollen mother-cell. The fact that occasionally in Helleborus cell-division does not take place until after the second mitosis serves to show more definitely the close resemblance between embryo-sac and pollen mother-cell (Mottier, '98, *fig. 31*).

Juel (1900) has shown that the two successive divisions in the macrospore mother-cell of Larix gives rise to four cells in the same manner as in such angiosperms as Helleborus, and that the first of these mitoses is heterotypic. This is probably true for many other gymnosperms.

It is well known that the developmental history of the embryo-sac between the macrospore mother-cell and the mature female gametophyte is shortened in certain cases by one or two nuclear divisions, and it is important to know, in these cases of abbreviated development, the place occupied by the two mitoses in question.

With this object in view Frau Schniewind-Thies (1900) has investigated the development of the embryo-sac in several species of the Liliaceae, and has brought together a number of interesting observations. In all cases examined by this author, the first two nuclear divisions in the mother-cell are heterotypic and homotypic respectively, and whenever four potential spores result, each nuclear division is followed by a cell-division. One of these potential macrospores, usually the lower one, develops, as in Helleborus, by three successive typical or ordinary mitoses into the embryo-sac. In the case of *Scilla sibirica*, however, the developmental history of the female gametophyte, or embryo-sac, is shortened by only one nuclear division. The first or heterotypic division is followed by a cell-division. Following the second, or homotypic mitosis, no cell-division takes place, and consequently each daughter cell contains two nuclei. Either of these cells may function as the macrospore, and develop into the embryo-sac, while the other is absorbed. In this case the homotypic division represents the first mitosis in the spore. The two daughter nuclei now divide twice in the typical way to give rise to the mature embryo-sac. In *Scilla sibirica*, therefore, there is a shortening of the development by one typical mitosis.

In Lilium and in other genera with a similar development of the embryo-sac, the process is further shortened. Here the macrospore mother-cell functions at once as the spore. No cell division follows the heterotypic or homotypic mitoses, although there is sometimes a tendency toward cell-plate formation (Mottier, '98), and these two nuclear divisions represent two out of the three divisions in the embryo-sac.

In the light of these facts, it seems clear that in Lilium there is merely a shortening of the development of the embryo-sac by two typical mitoses.

The development of the embryo-sac immediately from the mother-cell has probably no parallel in the case of the pollen, since Strasburger (1901) and Frye (1901) have recently shown that in Asclepias and in a few other genera, in which the pollen mother-cell was supposed to function as the spore, the usual process of the development of the pollen obtains.

SUMMARY.

In the karyokinetic processes occuring in the micro- and macrospore mother-cells of the angiosperms, certain phenomena may now be regarded as very well understood and pretty definitely established.

In the first place, the nuclear spindle arises as a multipolar complex of fibers, wholly or almost wholly of cytoplasmic origin, which is gradually transformed into the typical bipolar spindle. No centrospheres or centrosomes are present.

During the first mitosis the reduced number of chromosomes appears. There is no reduction or qualitative division in the sense of Weismann. The first division is characterized further by two longitudinal divisions of the chromatin, the second longitudinal splitting being at right angles to the plane of the first.

The first longitudinal fission occurs in the early prophase; the second is demonstrable in the mature spindle when the chromosomes are arranged in the nuclear plate, or first during the meta- or anaphase. Sometimes evidence of the second splitting appears at an earlier stage, but these are not conclusive.

The second longitudinal fission seems to be a preparation for the second or following mitosis.

The first division is also characterized by the long period of growth during the prophase, resulting in an increase in the size of the nucleus and in the quantity of chromatin.

The granddaughter chromosomes, having arrived at the poles, unite end to end to form a continous daughter spirem in Lilium and in Podophyllum. In all species examined all identity of the individual chromosomes is lost in the daughter nucleus. In Podophyllum and even in Lilium the granddaughter chromosomes show a marked tendency to reticulate, becoming irregular, while in Tradescantia and in the embryo-sac of Lilium the reticulation of the chromatin is continued to such an extent that the daughter nucleus passes almost into the structure of the resting stage.

The chromatin thread or spirem of the daughter nucleus does not undergo a longitudinal fission. During the development of the spindle and in some cases earlier, the daughter spirem segments into the granddaughter chromosomes, which are gradually arranged in pairs in the nuclear plate by means of the spindle fibers. As the granddaughter chromosomes are conveyed to the poles during the anaphase, they are usually in the form of rods, which may be straight, undulating, hooked at one end, or sometimes U- or V-shaped.

The first mitosis in both the micro- and macrospore mother-cells of the higher plants is, therefore, heterotypic, and the second homotypic. These nuclear divisions are not, properly speaking, reducing or reduction divisions. They are not the agents of the reduction, but rather the result of the numerical reduction of the chromosomes.

In the plants which were the objects of investigation, it is clear that the various forms of chromosomes observed in the heterotypic mitosis are such that might suggest more than one valid interpretation, and it is in a large measure due to this fact that there still prevail different and opposing interpretations in plants as well as in animals. The history of the development of the chromosomes, and a more thorough knowledge of their behavior during every phase of karyokinesis have shown that the shape which they may assume is of secondary importance. The form of each chromosome depends chiefly upon the shape of the daughter segments and their orientation toward each other and the manner in which the chromosome is fastened to the spindle.

In Lilium the daughter segments are, as a rule, rather long rods closely applied to and twisted upon each other. As shown in the preceding pages, there are many variations from the usual form. They are generally fastened to the spindle fibers at the end, and under such circumstances placed radially upon the spindle.

During metakinesis, the second longitudinal fission manifests itself, and each daughter chromosome consists of two granddaughter segments, which usually adhere and sometimes fuse at the ends to which the spindle fibers are fastened, while the opposite ends may diverge to form the V- or U-shaped figures. It often happens that the free ends of the granddaughter segments do not diverge, in which case the retreating daughter chromosome is in the form of two contiguous or nearly contiguous rods. Sometimes the ends of the granddaughter segments appear so completely fused near the place of fastening to the spindle that the daughter chromosome resembles a continuous rod bent into the shape of a V or U. On the other hand, V- and U-shaped daughter chromosomes are brought about by another process, namely, that of a bending. Under this circumstance the chromosomes are attached to the spindle, not by the ends, but near the middle or at some distance from one end, and the orientation upon the spindle is generally tangential. The V- or U-form is then due either to a previous bending of each daughter segment in such a manner as to form a ring or loop, or the bending may be caused by a pushing or pulling of the spindle fibers during the meta- or anaphase. In all such cases the V's or U's so formed are double as a result of the second longitudinal splitting.

The fact that in many plants the daughter nucleus passes into the resting stage would seem to indicate that the second or homotypic mitosis signifies something more than the mere distribution of the granddaughter chromosomes to the granddaughter nuclei. In such cases it is difficult to understand the purpose of two longitudinal fissions during the first karyokinesis.

It is generally assumed that the two granddaughter segments of each chromosome appearing in the nuclear plate of the second mitosis are sisters and identical with the pairs of segments of the anaphase of the first division. This can only be true when the spirem segments in exactly the same manner in which it was constructed, assuming that the pieces separated by the breaking up of the spirem consist of the two segments of each chromosome. But on the other hand, if the spirem break up so that the individual segments are separated from the start, then sister segments may be brought together in pairs in the nuclear plate. It is evident in many instances that the pieces into which the spirem falls does consist of the two segments of each chromosome in the second division, and that these are brought side by side by the folding of the piece or by the two parallel members of a loop or turn approaching each other.

However, as has been pointed out in a preceding paragraph, should the spirem segment in a different manner with each piece representing two segments, the two segments of the chromosomes would not necessarily be sisters. In such cases, the possibility is not excluded that two or more sister chromosomes may fall to the same nucleus. Moreover, as the identity of the individual chromosomes is lost in the daughter nucleus, it is not possible to demonstrate objectively whether the segments are sisters or not.

There is also no basis in fact which will justify the doctrine that one chromosome is qualitatively different from another.

The development of the spindle seems to show that the chromosomes are oriented in the nuclear plate by a pushing and pulling action of the spindle fibers. There is some evidence to indicate also that during the anaphase a pushing is exerted upon the retreating segments, yet this view can not be accepted without the greatest reserve, as the presence of a large bundle of fibers extending from each daughter segment to the poles argues strongly in favor of a pulling or contracting of the fibers.

According to the best cytological evidence the micro- and macrospore mother-cells are homologous. That type of development of the embryo-sac in which four potential macrospores are produced as the result of the heterotypic and homotypic mitoses, occurring in gymnosperms as well as in the majority of angiosperms, is regarded as the more primitive, while that typified by Lilium is interpreted as a derived condition.

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⁂ In justice to the author it should be stated that the publication of the foregoing paper has been prevented for six months by unreasonable delay in the lithographing of the plates.—EDS.

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EXPLANATION OF PLATES XI–XIV.

All figures were drawn from sections with the aid of the Abbé camera lucida and with Zeiss apochromatic homogeneous immersion 2 mm., apert. 1.40, with compensating oculars 6 and 8, or with Leitz homogeneous immersion $\frac{1}{16}$ and oculars 1 and 3.

FIGS. 1–18. Pollen mother-cell of *Lilium Martagon*. *Figs. 1–11* refer to the first mitosis; *12–18* to the second.

FIG. 1. *a*, *b*, *c*, and *d* represent four chromosomes shortly after the cross segmentation of the spirem; in *a* the daughter segments are somewhat closely applied and twisted upon each other; in *b* the ends show a tendency to separate and diverge; and in *c* the segments are almost separate save at one end; *d* is a case in which the chromosome is somewhat bent and the segments are in close contact near the middle. × about 1750.

FIG. 2. Various forms of chromosomes observed in the nuclear plate: *a*, the chromosome is fastened to the spindle at the end, and consists of two rod-shaped segments twisted upon each; *b*, the two segments which adhere at both ends bend out at the middle to form the ring-shaped chromosome; such chromosomes are generally placed tangentially upon or within the spindle; *c* to *h* represent several other forms of chromosomes commonly met with; the bundle of fibers shows the method of attachment to the spindle; *f* is an X-shaped chromosome, although in this form of chromosome the ends may diverge more; *h* is a typical Y-shaped chromosome. *a* and *b*, × 1750; *c* to *h*. × 1500.

FIG. 3. A nearly mature spindle; the chromosomes are being arranged in the nuclear plate. × 1500.

FIG. 4. A mature spindle showing only three chromosomes. × 1500.

FIG. 5. Chromosomes in metakinesis; each daughter chromosome consists of two granddaughter segments as the result of the second longitudinal splitting; the granddaughter segments adhere at the ends to which the bundle of spindle fibers is fastened, while the opposite ends diverge to form the familiar V-shaped figures; the chromosomes in this figure are all fastened to the spindle by the ends. × 1500.

FIG. 6. Two chromosomes from a karyokinetic figure in the same stage as *fig. 5*; the chromosome at the right was fastened endwise to the spindle, and consequently the retreating pairs appear as two rods lying side by side or as V-like figures; the chromosome at the left was in the form of either a complete open or an incomplete ring: the daughter segments are therefore somewhat U- or V-shaped with one limb of the U, or V a little longer than the other; the V-shape here is due to a bending; each U or V is double as a result of the second longitudinal fission. × 1750.

FIG. 7. Median section of an entire pollen mother-cell. The chromosomes are in the anaphase; the granddaughter segments form V's or pairs of nearly parallel rods. × 1500.

FIG. 8. The same stage as the preceding; the daughter chromosomes on the right and left consist each of two U- or hook-shaped granddaughter segments owing this form to a bending; the granddaughter segments of those in the middle are contiguous rods slightly bent or hooked at one end. × 1500.

FIG. 9. Five daughter chromosomes nearly at the poles; the granddaughter segments which are at a slight distance apart are connected by fine threads. × 1750.

FIG. 10. The granddaughter segments are forming the spirem of the daughter nucleus by uniting end to end; between the daughter spirems extends the system of connecting fibers. × 1500.

FIG. 11. Daughter nucleus seen obliquely from the pole side; the spirem is arranged chiefly in long and regular turns. × 1750.

FIG. 12. A multipolar spindle of the second mitosis; the loops and turns of the partly segmented spirem are entangled; some of the free ends were made by the knife in sectioning; as a rule at this stage the spirem is much more entangled and kinked, so that it is impossible to trace the individual pieces; the chromosomes are probably being pushed into the nuclear plate. × 1750.

FIG. 13. The spindle is bipolar, but the chromosomes are not completely oriented into the nuclear plate; it seems also that the spirem is not wholly segmented.

FIGS. 14, 15. The spindle is about mature, and the arrangement of the chromosomes is typical except that they are very often much more irregular, twisted, and kinked; in these two figures it is clearly seen that some of the segments of the chromosomes are twisted upon each other, while others are separate, lying tangentially (*fig. 14*) upon opposite sides of the equator. × 1750.

FIG. 16. Chromosomes in metakinesis; the separating elements are often variously bent or curved.

FIGS. 17, 18. Two spindles in anaphase; the retreating chromosomes are more or less curved or undulating rods which are almost invariably slightly hooked at the ends to which the fibers are attached.

FIGS. 19–29. Pollen mother-cell of *Podophyllum peltatum*. *Figs. 19–24* refer to the first, and *25–29* to the second division.

FIGS. 19, 20. Mature spindles; in *fig. 19* the chromosomes on the right and left are ring-shaped; in the central one the segments are in contact at only one end and each is curved; the picture presented by the nuclear plate of *fig. 20* is perhaps more frequent and typical; here also the chromosomes adhere at one end only; the segments are almost invariably curved, and the ends in contact are sometimes fused in such a way as to present a lump or swollen place. × 1500.

FIG. 21, *a* and *b*. Two chromosomes in metakinesis; the second longtudinal fission is plainly manifested; the chromosome *a* was oriented as in *fig. 20*; that at *b* was probably fastened to the spindle by one end, and stood radially to its axis; the retreating daughter chromosomes of *a* will be double U's, while those of *b* will probably give V's, or merely pairs of parallel and contiguous rods. × 1500.

FIGS. 22, 23. Two karyokinetic figures in anaphase; the two granddaughter segments of each daughter chromosome are clearly seen at this stage; they are either somewhat U-shaped, straight, or slightly curved rods. × 1250.

FIG. 24. Three chromosomes at a little later stage seen obliquely from the pole. × 1250.

FIG. 25. Daughter nucleus showing hollow spirem; the free ends indicate where the spirem was cut by the microtome knife.

FIG. 26. An entire pollen mother-cell showing the two multipolar spindles of the daughter nuclei. × 1750.

FIG. 27. A multipolar spindle of a daughter nucleus at a later stage than the preceding, in which fewer poles are present; the chromosomes are being arranged in the nuclear plate.

FIGS. 28, 29. Two mature spindles; although in *fig. 29* the segments of the chromosomes are not closely applied to each other, yet this is not a later stage than *fig. 28*.

FIGS. 30–39. *Tradescantia virginica.*

FIG. 30. Mature spindle; the points of the crescent-shaped daughter segments adhere to form ring-like chromosomes except in the one at the right; two of the chromosomes are fastened together by the fusion of one of the points of each crescent to one of the other; in the chromosome at the right only one point of the segments adhere. × 1250.

FIG. 31. The same stage as *fig. 30;* the daughter segments of the three chromosomes on the left are united only at one end; they are short, thick crescents with blunt ends, and when thus oriented they frequently reach almost from pole to pole. × 1250.

FIG. 32. The daughter segments have just separated; at this stage the second longitudinal fission is often not apparent. × 1250.

FIG. 33. The anaphase; at this stage it is evident that the daughter chromosomes have split lengthwise. × 1250.

FIG. 34. The same stage as *fig. 33;* the chromosomes are seen from the pole. × 1250.

FIG. 35. Daughter nucleus seen from the pole: the granddaughter segments of the twelve chromosomes show a tendency to become separated; their surfaces present an eroded appearance. × 1750.

FIG. 36. Daughter nucleus in which the chromosomes are much reticulated and the identity of the individuals cannot be definitely made out. × 1750.

FIG. 37. Daughter nucleus in which all identity of the chromosomes is lost. × 1750.

FIG. 38. The chromosomes are differentiated preparatory to the formation of the spindle. × 1750.

FIG. 39. Mature spindle of second mitosis; the chromosomes are longer and more regular than is usual. × 1750.

FIGS. 40–46. Embryo-sac of *Lilium Martagon.*

FIG. 40. Mature spindle of first karyokinesis in embryo-sac; the chromosomes stand radially upon the spindle. × 1500.

FIG. 41. The anaphase of the same division; the pairs of granddaughter segments are similar to those in the pollen mother-cells.

FIG. 42. Embryo-sac with two daughter nuclei which are nearly in the resting condition; the connecting fibers have not entirely disappeared; less highly magnified.

FIG. 43. An upper daughter nucleus in an early stage of spindle-formation; the nuclear membrane as such has disappeared, and numerous spindle fibers have penetrated the nuclear cavity; the chromatin spirem is not segmented; the free ends have been made by the knife. × 1500.

FIG. 44. Bipolar spindle of second division; the spirem does not seem completely segmented. × 1500.

FIG. 45. A mature spindle; the chromosomes are regularly oriented in the nuclear plate; the long, slender segments are contiguous and twisted upon each other. × 1500.

FIG. 46. The same in metakinesis. × 1500.

BRIEFER ARTICLES.

NOTES ON NORTH AMERICAN GRASSES.

III. NEW SPECIES OF WILLKOMMIA. (WITH TWO FIGURES.)

Willkommia texana Hitchc., n. sp.—A tufted perennial. Culms smooth, a foot or two high, erect from a decumbent base. Radical

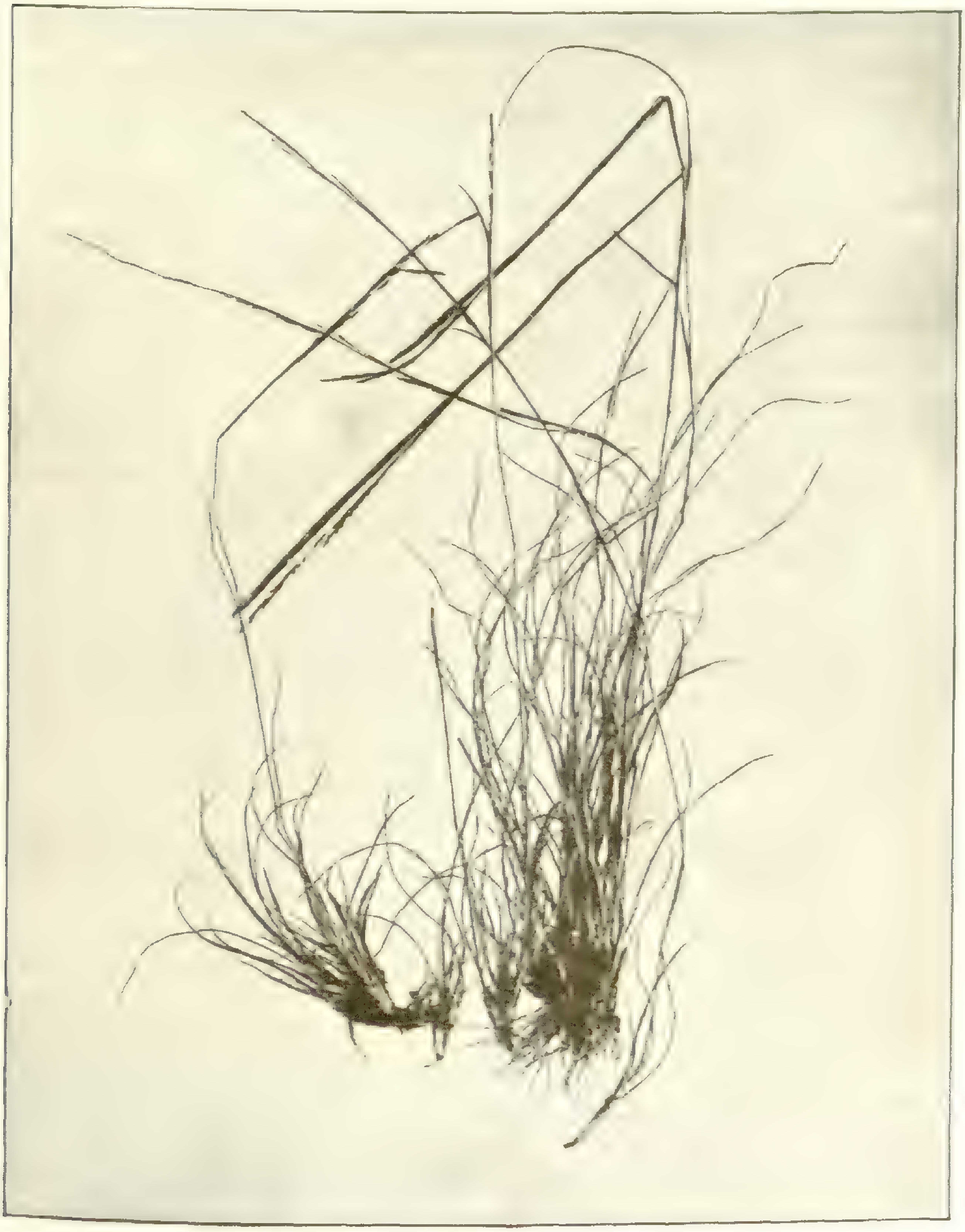

FIG. 1.—*Willkommia texana* Hitchc.

leaves several, 3 or 4 inches long, involute, tapering to a sharp point, upper surface rough, margin scabrous, otherwise smooth. Stem leaves few, the upper larger and embracing the lower part of the panicle. Inflorescence a panicle of spikes, a few inches to a foot long. Spikes several, an inch or two long, distributed along the axis. Spikelets several, arranged in two rows along one side of a flattened axis, 1-flowered, appressed. Empty glumes 2, 1-nerved, smooth, thin, and light colored, pointed but not awned, lower about half as long as upper, which is green on the margins. Flowering glume about the length of the upper empty glume, obtuse and awnless, 3-nerved, the lateral pair near the margin and densely ciliate with long white hairs, also pubescent between nerves. Palea nearly as long as flowering glume, 2-keeled, the nerves ciliate like the flowering glume. The base of the flower extends down into a short, hairy callus. Stamens 3. Caryopsis oblong, smooth, margined, and apiculate above.

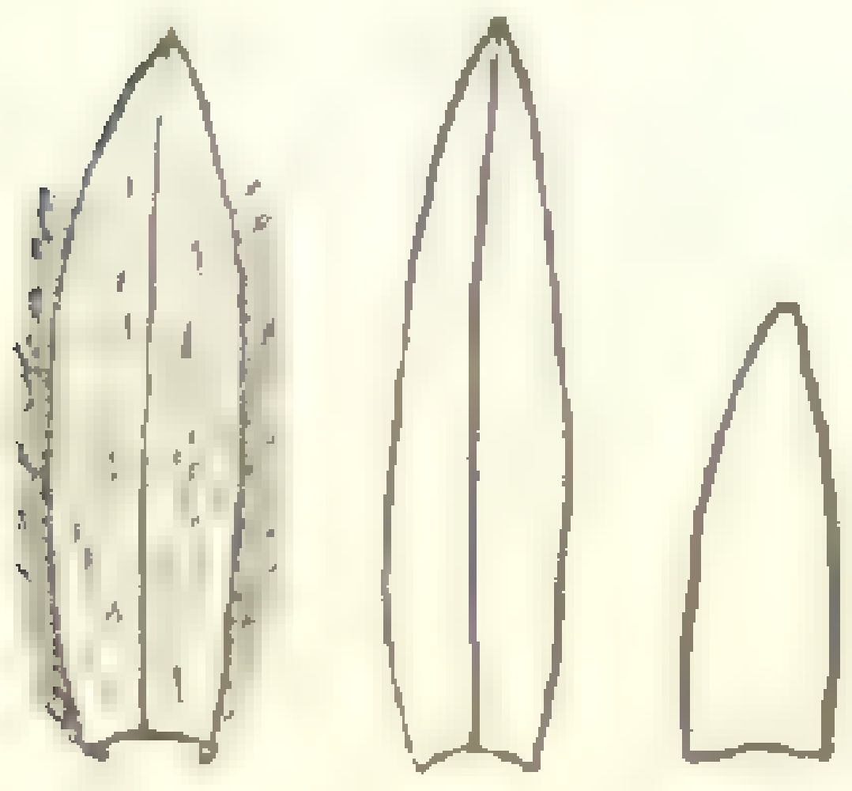

FIG. 2. — Details of flower.

DISTRIBUTION: Ennis and Beeville, Texas, *J. G. Smith*, 1897.

The specimens were found among the undetermined forms of Leptochloa in the Herbarium of the U. S. Department of Agriculture. The plant from Ennis may be considered the type. I have referred this species to Hackel's genus Willkommia as it agrees with the description in all essential particulars, and in generic characters with the specimen of *Willkommia annua* which is in the Department Herbarium. In floral characters it differs chiefly in the awnless flowering glume. The distribution of the genus is peculiar, as the three previously described species occur in west South Africa.

The genus Willkommia was described by Hackel, Verh. Bot. Ver. Brandenburg 30: 145. 1888. This name had already been applied to a group of Compositæ (Sch. Bip. ex Nym. Consp. 357. 1879), which is now generally referred to Senecio. Hackel was aware of this, but, from the fact that the earlier name was now a synonym, considered himself justified in taking up the same name for his new genus of grasses.

This genus is allied to *Schedonnardus* Steud. and *Craspedorachis* Benth., but is distinguished from the former by the broad, hyaline, unequal empty glumes and the densely ciliate flowering glume and palea, and from the latter by the unequal empty glumes and the flowering glume as long as the upper empty glumes. Craspedorhachis has equal empty glumes twice as long as the flowering glume and palea.

I am of the opinion that Willkommia should be referred to Craspedorhachis Benth. (Hook. Icon. Pl. III. 4: 58. *pl. 1377.* 1882), but as Hackel, who has had the opportunity of examining all the African species, has kept the two genera separate I have done the same.

Hackel describes a second species of Craspedorhachis, *C. Menyharthii*, Bull. Herb. Boiss. II. 1: 770. 1901, from southeast Africa, in which the flowering glume is only one-fourth to one-fifth shorter than the outer glumes, thus making the difference less between our plant and the genus Craspedorhachis.—A. S. HITCHCOCK, *Bureau of Plant Industry, U. S. Department of Agriculture.*

THE MORPHOLOGY OF SPORE-PRODUCING MEMBERS.

[In view of the fact that Professor Bower's last paper,[1] which contains the general conclusions from his studies of spore-producing members, is not likely to appear for some time, we venture to publish in advance the following abstract of the memoir, which was read before the Royal Society on February 12, 1903, and kindly communicated to us.—EDS.]

THIS concluding memoir contains a general discussion of the results acquired in the four previous parts of this series, and of their bearing on a theory of sterilization in the sporophyte. The attempt is made to build up the comparative morphology of the sporophyte from below, by the study of its simpler types; the higher and more specialized types are left out of account, except for occasional comparison. It is assumed for the purposes of the discussion that alternation of generations in the Archegoniatae is of the antithetic type, and that apogamy and apospory are abnormalities, not of primary origin.

After a brief allusion to facts of sterilization in the sporogonia of bryophytes the similar facts are summarized for the pteridophytes. It has been found that examples of sterilization of potentially sporogenous cells are common also in vascular plants, while occasionally cells which are normally sterile may develop spores. Hence it is concluded that spore-production in the archegoniate plants is not in all cases strictly limited to, or defined by, preordained formative cells, or cell-groups. A discussion of the archesporium follows, and though it is found that in all Pteridophyta the sporogenous tissue is ultimately referable to the segmentation of a superficial cell, or cells, still in them, and indeed in vascular plants at large, the segmentations which lead up to the formation of spore mother cells are not comparable in all cases; in fact, that there is no general law of segmentation underlying the existence of that cell or cells which a last analysis may mark out as the "archesporium"; nor do these ultimate parent cells give rise in all cases to cognate products. Therefore it is concluded that the general application of a definite term to those ultimate parent cells which the analysis discloses has no scientific meaning, beyond the statement of the histogenic fact.

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[1] BOWER, F. O., Studies in the morphology of spore-producing members. No. V. General comparisons and conclusions.

Further, it is shown that the tapetum is not a morphological constant, but varies both in occurrence and origin; that even the individuality of the sporangium is not always maintained. All that remains then as the fundamental conception of the sporangium in vascular plants is the spore mother cell or cells, and the tissue which covers them in, for such cells are always produced internally. The definition of the sporangium may then be given thus: "*Wherever we find in vascular plants a single spore mother cell, or connected group of them, or their products, this with its protective tissues constitutes the essential of an individual sporangium.*" From the point of view of a theory of sterilization such sporangia may, at least in the simplest cases, be regarded as islands of fertile tissue which have retained their spore-producing character, while the surrounding tissues have been diverted to other uses. It will be seen later how far this view will have to be modified in the more complex cases.

In a second section of the memoir the variations in number of sporangia in vascular plants are discussed; the methods of variation may be tabulated as follows, under the heads of progressive increase and decrease:

I. *Increase in number of sporangia.*—(*a*) By septation, with or without rounding off of the individual sporangia; (*b*) by formation of new sporangia, or of new spore-bearing organs, which may be in addition to or interpolated between those typically present; (*c*) by continued apical or intercalary growth of the parts bearing the sporangia; (*d*) by branching of the parts bearing the sporangia; (*e*) indirectly, by branchings in the non-sporangial region resulting in an increased number of sporangial shoots; this is closely related to (*c*) and (*d*).

II. *Decrease in number of sporangia.*—(*f*) By fusion of sporangia originally separate; (*g*) by abortion, partial or complete, of sporangia; (*h*) by reduction or arrest of apical or intercalary growth in parts bearing sporangia; (*i*) by fusion of parts which bear the sporangia or arrest of their branchings; (*j*) indirectly, by suppression of branchings in the non-sporangial region, resulting in decreased number of sporangial shoots; this is closely related to (*h*) and (*i*).

We are justified in assuming that (subject to the possibility of other factors having been operative of which we are yet unaware) the condition of any polysporangiate sporophyte as we see it is the resultant of modifications such as these, operative during its descent. The problem will, therefore, be in each case to assign its proper place in the history to any or each of these factors.

It is pointed out that in homosporous types, which are certainly the more primitive, the larger the number of spores the better the chance of survival, and hence, other things being equal, increasing numbers of spores and of sporangia may be anticipated; but in the heterosporous types reduction in number both of spores and of sporangia is frequent. The former will accordingly illustrate more faithfully than the heterosporous forms the story of the increase of complexity of spore-producing parts. The general method put in practice here is to regard homosporous forms as in the upgrade of their evolution, as regards their spore-producing organs, unless there is clear evidence to the contrary. The *onus probandi* lies rather with those who assume reduction to have taken place in them.

A summary of evidence of variation in number of sporangia by any of these methods is then given for the Lycopodineae, Psilotaceae, Sphenophylleae, Ophioglossaceae, Equisetineae, and Filicineae; followed in each case by a theoretical discussion of the bearing of that evidence on the morphology of the spore-producing members. The general result is that all of them, including even the dorsiventral and megaphyllous types, are referable to modifications of a radial strobiloid type; progressive elaboration of spore-producing parts, followed by progressive sterilization, and especially by abortion of sporangia in them, of which there is frequent evidence, together with the acquirement of a dorsiventral structure, may be held to account for the origin of even the most complex forms. But the vegetative organs once formed may also undergo elaboration, and differentiation *pari passu* with the spore-producing organs, a point which has greatly complicated the problem, especially in the higher forms; all roots are probably of secondary origin; facts of interpolation of additional sporangia, especially in ferns, and of apogamy and apospory, are also disturbing influences which have probably been of relatively recent acquisition.

A comparison is drawn, as regards position, physiological and evolutionary, in the sporophyte, between the fertile zone in certain bryophytes and the fertile region of certain simple pteridophytes, *e. g.*, the lycopods; though no community of descent is assumed, the relation of the reproductive to the vegetative regions is the same. In the bryophytes that region is regarded as a residuum from progressive sterilization; it is suggested that the same is the case for a strobiloid pteridophyte, such as Lycopodium. The theory of the strobilus, based on this comparison, is that similar causes would lead to the decentralization of the fertile tissue in the primitive pteridophytes as in the bryophytes, and result in the formation of a central sterile tract, with an archesporium, at its periphery; that such an archesporium, instead of remaining a concrete layer as it is in the larger Musci, became discrete in the lycopods; that the fertile cell-groups formed the centers of projecting sporangia, and that they were associated regularly with outgrowths, perhaps of correlative vegetative origin, which are the sporophylls.

Whether or not this hypothesis of the origin of a lycopod strobilus approaches the actual truth, comparison points out the genus Lycopodium as a primitive one, characterized by more definite numerical and topographical relation of the sporangia to the sporophylls than in any other type of Pteridophyta.

Then follows, as a consequence of comparison, the enunciation of a theory of the sporangiophore, a word which is here used in an extended sense to include not only the spore-producing organs of Psilotaceae, Sphenophylleae, Ophioglossaceae, Equisetaceae, but also the sori of ferns. The view is upheld that all these are simply placental growths, and not the result of "metamorphosis" of any parts or appendages of prior existence; that the vascular supply, which is not always present, is not an essential feature; that they are seated at points where in the ancestry spore-production has been proceeding on an advancing scale; hence they do not occupy any fixed and definite position. It seems probable that at least a plurality of sporangia existed on primitive sporangiophores, and that where only one exists that condition has been the result of reduction.

The above theories are then applied to the several types of Pteridophyta. The Lycopods, Psilotaceae, Sphenophylleae, and Ophioglossaceae may be arranged as illustrating the increased complexity of the spore-producing parts, and of the subtending sporophylls; the factors of the advance from the simple sporangium to the more complex sporangiophore are septation, upgrowth of the placenta with vascular supply into it, and branching, with apical growth also in the Ophioglossaceae. But even in the most complex forms, the sporangiophore may be regarded as a placental growth, and not the result of transformation of any other member.

In the case of Helminthostachys the marginal sporangiophores are regarded as amplifications from the sunken sporangia of the Ophioglossum type; in Equisetum they are regarded as being directly seated on the axis, and having originated there by a similar progression; they would thus be non-foliar. It is pointed out that though a foliar theory would be possible for Equisetum itself, it is not applicable to the facts known for the fossil Calamarieae, which are so naturally related to it. Thus the strobilus of the Equisetineae is of a rather different type from that of the Lycopods, Psilotaceae, or even the Ophioglossacae, in all of which there is a constant relation of the spore-producing parts to the leaves; in the Equisetineae no such constant relation exists; the leaves and sporangiophores may be in juxtaposition, as in Calamostachys, without exactly matching numerically; or the sporangiophores may occur in larger numbers and in several ranks, between successive leaf-sheaths, as in Phyllotheca and Bornia; or without any leaves at all, as in Equisetum. Thus, on a non-phyllome theory the latter may be held to be only an extreme case of what is seen in certain fossils.

The ferns, notwithstanding their apparent divergence of character from other pteridophytes, may also be regarded as strobiloid forms, with greatly enlarged leaves; the primitive sori of the Simplices resemble the sporangiophores of other Pteridophyta; the more complicated soral conditions of the Gradatae and Mixtae were probably derivative from these, the chief difference being due to the interpolation of new sporangia, an innovation which is in accordance with biological probability, as well as with the palaeontological record.

The effect of the results thus obtained on the systematic grouping of the pteridophytes is then discussed; it is pointed out that the lycopods, Psilotaceae, Sphenophylleae, Ophioglossaceae, and Filices illustrate lines of elaboration of a radial strobiloid type, with increasing size of the leaf. The division of Pteridophyta by Jeffrey, on anatomical characters, into small-leaved Lycopsida, and large-leaved Pteropsida is quoted; but it is concluded that the anatomical distinction of Jeffrey does not define phylogenetically distinct races, but is rather a register of such leaf-development as differentiated them from some common source. It is contended that the Ophioglossaceae and Filices, which constitute Jeffrey's Pteropsida, are not necessarily akin on the ground of their large leaves, and consequent phyllosiphonic structure; but that they probably acquired the megaphyllous character along distinct lines. The opinion of Celakovsky is still held, "that the lycopods are probably of living plants the nearest prototypes of the Ophioglossaceae." The more recent investigations of Jeffrey and of Lang have shown, however, that in the gametophyte of the Ophioglossaceae there is an assemblage of "filicinean" characters, which differ from those of Lycopodium itself. But Celakovsky's comparison is *with the lycopods, not with the genus Lycopodium;* so far as the facts go, increasing "filicinean" characters of the gametophyte follow in rough proportion to the larger size of the leaf; thus from Isoetes we learn that a combination of cross-characters is found in a megaphyllous lycopod type. What we find in the Ophioglossaceae is that in conjunction with their more pronounced megaphyllous form, still retaining, however, the lycopodinous type of the sporophyte, they show more pronounced "filicinean" characters of the gametophyte, and of the sexual organs. It is unfortunate that the facts relating to the gametophyte of the Psilotaceae and Sphenophylleae are not available in this comparison.

It is not obvious what the meaning is of this parallelism between leaf-size and characters of the sexual organs. A further difficulty in its interpretation lies in the fact that for the Equiseta the parallelism does not hold; there "filicinean" characters of the gametophyte accompany entirely non-filicinean characters of the sporophyte, the latter showing nearer analogy to the lycopods than to the ferns. Such cross-characters are difficult to harmonize with any phylogenetic theory; on account of them the Equisetineae are placed in an isolated position, and in the same way, though with less pressing grounds, a separate position should be accorded to those types which lie between the extremes of lycopods and ferns, in proportion as the characters are more or less pronounced.

On this basis the Isoetaceae would probably best take their place as a sub-series of the Lycopodiales, Ligulatae; the Psilotaceae and Sphenophylleae would constitute a series of Sphenophyllales, separate from, but related to, the Lycopodiales. The Ophioglossaceae would form an independent series of Ophioglossales more aloof than the latter from the Lycopodiales, but not included in the Filicales. The actual connection of these series by descent must remain open; it is quite possible that some or all of them may have originated along distinct lines from a general primitive group, which may be provisionally designated the Protopteridophyta; these were probably small-leaved strobiloid forms with radial type of construction, and with the sporangia disposed on some simple plan. The grouping arrived at in these memoirs may be tabulated as follows:

- I. Lycopodiales.
    - (*a*) Eligulatae.
        - Lycopodiaceae.
    - (*b*) Ligulatae.
        - Selaginellaceae.
        - Lepidodendraceae.
        - Sigillariaceae.
        - Isoetaceae.
- II. Sphenophyllales.
    - Psilotaceae.
    - Sphenophyllaceae.
- III. Ophioglossales.
    - Ophioglossaceae.
- IV. Filicales.
    - (*a*) Simplices.
        - Marattiaceae.
        - Osmundaceae.
        - Schizaeaceae.
        - Gleicheniaceae.
        - Matonineae.
    - (*b*) Gradatae.
        - Loxsomaceae.
        - Hymenophyllaceae.
        - Cyatheaceae.
        - Dicksonieae.
        - Dennstaedtiinae.
        - Hydropterideae (?).
    - (*c*) Mixtae.
        - Davallieae.
        - Lindsayeae.
        - Pterideae, and other Polypodiaceae.
- V. Equisetales.
    - Equisetaceae.
    - Calamarieae.

—F. O. Bower, *University of Glasgow.*

CURRENT LITERATURE.

BOOK REVIEWS.

Influence of light and darkness.

The relation of light to the growth and development of plants has been the subject of much study and experimental research for two centuries or more. Probably the largest contribution to the general knowledge of the subject, at least to the text-book literature, has been made by Sachs, aided by his pupils. He began publication in 1859, and exerted great influence in molding scientific opinion in this as in other parts of the science of plant physiology. As researches have multiplied and the subject has unfolded, the difficulty of making a satisfactory explanation of observed phenomena has increased.

A careful examination of the whole subject, coupled with observations upon a series of plants of wide relationship and diverse habits, has been much needed. A monographic work of this character has recently been published by Dr. D. T. MacDougal,[1] director of the laboratories of the New York Botanical Garden. It has been the aim of the author to secure ample facts with which to survey the whole field, and the substantial volume before us is evidence of success.

The work opens with a résumé of previous contributions, in which more than a hundred works are summarized in a lucid and critical manner. The author then records his own observations, giving an account of experiments on ninety-seven species of flowering plants, ferns and their allies, which have been grown in continual darkness, with control plants grown in light. The subjects were grown from tubers, corms, rhizomes, cuttings of leaves and stems, seeds, and spores. They represent aquatics, creepers, climbers, succulents, mycorhizal forms, geophilous and aerial shoots, mesophytes, and spiny xerophytes. The work has extended over a period of seven years, and embraces a wealth of data not readily apprehended without detailed examination. The great number of excellent original illustrations adds interest and value to the treatise.

A third of the volume is occupied with a discussion of the data, and their correlation with previous observations and conclusions. The matter is taken up from various points of view, and it is clearly shown that no theories heretofore propounded will apply to all cases. Although occasionally plants have acquired certain advantages through etiolation, the forms assumed in darkness are not, as usually held, due to an effort on the part of the plant to reach the light. It is shown that the stimulating action of light may be transmitted through a considerable interval of both space and time, even affecting organs subsequently formed, so that conclusions drawn from so-called "partial etiolation" have frequently been erroneous. Often there is a direct action of darkness in producing morphological changes. It is well proven that in all cases a great difference exists in the morphological differentiation of tissues developed in darkness and in light, and in this discussion the distinction between growth and development is kept clearly in view. The author concludes that "none of the phenomena of etiolation or of diminished growth in light may be ascribed to the direct influence of light upon the tissues or cells concerned, but rather upon the organism as a whole."

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[1] MacDougal, Daniel Trembly, The influence of light and darkness upon growth and development. Memoirs of the New York Botanical Garden, II. Imp. 8vo. pp. 319, *figs. 176*. New York Botanical Garden. 1903. $2.00.

It is, however, impossible to give in a brief review any adequate idea of the author's views upon the various aspects of the subject. He himself has tacitly admitted the futility of such an attempt by not providing a summary for the reader.

There can be no question of the great value of this contribution by Dr. MacDougal to a most important part of plant physiology. The vast array of carefully planned observations forms a substantial contribution in itself and the discussion brings the subject into a new and clearer light. An ample index both to the literature cited and to the text and illustrations completes the volume.—J. C. ARTHUR.

The heaths of northern Germany.

THE FIFTH volume of *Vegetation der Erde* differs from those that have preceded in that a single formation is dealt with, rather than a country or a natural phytogeographic subdivision. Graebner[2] has made the north German heaths a special study for a number of years, and in 1895 he published an extensive treatise on the subject, wherein many of his present results were anticipated. The close relationship between heaths and moors is clearly shown, and the impossibility of using the water content of the soil as the chief distribution factor is well brought out. Graebner makes a strong plea (as he has done in former papers) for a chemical classification of soils and plant formations. Adopting this idea, the heath belongs to the soil group which is poor in certain food materials, particularly potash, lime, and phosphoric acid. For chemical reasons, he believes that a heath soil can never develop a natural forest. The author's concept of the heath is rather broad, including not only areas dominated by ericaceous shrubs, but open tracts in which there is neither a good tree growth nor a close grass turf; ligneous plants dominate, especially low shrubs. What we call pine or oak barrens would probably be included in Graebner's heath. Moors or peat bogs also are difficult to delimit from the heath, many species, indeed, being common to both.

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[2] GRAEBNER, P., Die Heide Norddeutschlands und die sich anschliessenden Formationen in biologischer Betrachtung. 8vo, pp. xii + 320. With map. Leipzig: Wilhelm Engelmann. 1901. Price *M* 21.50.

The most interesting of the chapters is the one which presents the dynamics of the heath formation. Graebner combats with great vigor the rather common view that heaths represent areas once forested, in which reforestation has been prevented directly or indirectly through the agency of man. He argues that most heath areas show no tendency to return to forests, when left quite free to do so, and that in many cases heaths even encroach upon forests. As already noted, the chemical nature of the soil is believed to be inimical to tree growth, and the *Ortstein* of the heath subsoil adds to the difficulty. The author departs from most commonly accepted views in regarding the climate as fundamentally responsible for the condition of these heathy soils. The most usual origin of the heath is from forests in which the soil has been made gradually poorer in necessary salts, partly by the trees themselves but more especially by leaching. The latter process is thought to be greater in northwestern than in northeastern Germany, because of greater rainfall. Hence the heath prevails westward under original soil conditions that bring forth forests eastward. The heath may originate on naked sand through a series of stages, the first of which is characterized largely by algae and moss protonemata. Graebner also shows how heath moors may originate, giving three cases: development from water, from naked soil, and from forests. The heath may develop from these moors, if for any reason they become dry. Sections are devoted to the soil species and climatic features of the heath region.

The second part of the book treats of the various types of heaths, which the author divides into four groups. (1) Heaths proper, including Calluna, Tetralix, Empetrum, and Sarothamnus heaths; (2) grass heaths, dominated by xerophytic grasses; (3) forest heaths, mostly dominated by pines; (4) Weingaertneria heaths. The final section deals with the relation of the heath to other formations. This volume is easily the most readable of those which have been thus far published, and it is to be hoped that other volumes which deal with definite formations will follow soon.—H. C. COWLES.

Vegetation pictures.

KARSTEN and SCHENCK[3] have inaugurated a valuable series of illustrations of the world's vegetation, of which two numbers have thus far appeared. Each number contains six excellent heliotypes, representing characteristic plant formations in various parts of the world. Full descriptive text accompanies each picture, so that reference to various original monographs is scarcely necessary. The first number, prepared by Schenck, deals with southern Brazil, presenting views of the tropical rainy forest, myrmecophilous trees, palms, epiphytes, and Araucaria woods. Karsten has given out the second number, which contains views from the Malay archipelago, presenting the Nipa formation, tree ferns, rainy forest and street scenes. The illustrations are usually well executed and will prove of great value in botanical classes.

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[3] KARSTEN, G., and SCHENCK, H., Vegetationsbilder. 4to. Jena: Gustav Fischer. 1903. Subskriptionspreis jedes Heft von 6 Tafeln *M* 2.50. Einzelne Hefte *M* 4.

The vegetation of east Africa, so long poorly known, but now so fully brought to light by the work of Dr. Engler and his associates, is presented yet more clearly by an excellent series of 64 reproductions from photographs, taken by Walther Goetze, who lost his life while engaged in this work.[4] Among the views here presented are coastal steppes, high grass steppes, Acacia and other tree steppes, palm woods, Euphorbia thickets, alluvial forests, mountain woods and thickets, mountain meadows, rainy forests, etc. Good text descriptions accompany the views, and it is safe to say that one may get from a careful study of this work a vivid and true picture of many of the plant formations of German East Africa.—H. C. Cowles.

MINOR NOTICES.

A. J. McClatchie[5] has brought together a large amount of interesting information concerning Eucalyptus. The purpose of the bulletin is to give information concerning the characteristics of the "eucalypts," their climatic requirements, and their uses; to give directions and suggestions as to their propagation and culture; and to furnish a means of identifying seedlings and mature trees. It seems that these trees now serve very many useful purposes in the Southwest, and give promise of great future usefulness in the semi-arid portions of our continent. The covering of the now untillable treeless portions of the semi-tropic section of America with such trees as eucalypts, which will yield fuel, timber, and other useful products, and also furnish protection from the sun, from winds, and from floods, or otherwise ameliorate existing climatic conditions, is certainly an achievement greatly to be desired. The characteristics of forty-one species, being the principal ones grown in America, are discussed, and illustrated by the ninety-one handsome reproductions of photographs.—J. M. C.

Hildebrand[6] has published under the title *Aehnlichkeiten im Pflanzenreich*, a volume rather out of the ordinary in the nature of its contents. The material presented is familiar to botanists, and yet would not particularly attract the popular reader. The stock cases of similarity in general habit, and in various organs (such as cacti and euphorbias, leaves and phylloclades, raspberries and mulberries, chestnuts and horse chestnuts) are marshalled under different headings; a section is likewise devoted to similarities between plants and animals. The conclusions deal with causes and uses. Aside from genetic relationship and similar life conditions, the author thinks that hidden inner causes also cause similarities (e. g. in the pods of legumes and crucifers). The author thinks that likenesses, like many other things in plants, are generally useless, and that there is nothing analogous to the use of mimicry by animals.—H. C. COWLES.

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[4] Engler and Goetze, Vegetationsansichten aus Deutschostafrika inbesondere aus der Khutusteppe, dem Ulugurugebirge, Uhehe, dem Kingagebirge, vom Ruogwe, dem Kondeland und der Rukwasteppe, nach 64 von Walther Goetze auf der Nyassa-See und Kinga-Gebirgs-Expedition der Hermann und Elise geb. Heckmann Wentzel-Stiftung hergestellten photographischen Aufnahmen.

[5] McClatchie, A. J., Eucalypts cultivated in the United States. U. S. Dept. of Agric., Bureau of Forestry, Bull. 35. pp. 106. *pls. 91.* 1902.

[6] Hildebrand, F., Ueber Aehnlichkeiten im Pflanzenreich. 8vo. pp. iv+66 Leipzig: Wilhelm Engelmann. 1902. Price *M* 1.60.

M. LE PROFESSEUR ABBÉ H. LÉVEILLÉ[7] has begun the publication of an elaborate monograph of the genus Onothera, all of whose species are American, with the exception of a single Tasmanian species. This first fascicle comprises 138 pages, with numerous heliogravure plates and text cuts. After an analysis of Spach's monograph of 1835, and a general statement concerning anatomical characters and those from the seed the genus is presented under its five grand divisions (Scutiformes, Nuciformes, Laterniformes, Siliquiformes, and Prismatiformes). The species of each division are then presented and illustrated, the fascicle ending in the midst of the third group. The second fascicle is promised early in 1903, and the third in February 1904.—J. M. C.

H. VON SCHRENK[8] has published an account of a disease of the white ash caused by *Polyporus fraxinophilus*, which is very prevalent in the Mississippi valley, and is particularly severe in Missouri, Nebraska, and eastern Kansas, fully 90 per cent. of the trees in some localities being affected. The bulletin discusses the geographical distribution of the disease, susceptibility to this disease, method of attack, diseased wood, the sporophore, microscopic changes in the wood, growth of the fungus in dead wood, and remedies. —J. M. C.

THE LAMENTED DEATH of Dr. K. Gustav Limpricht is fortunately not to interfere with the completion of his work, *Die Laubmoose*, in Rabenhorst's *Kryptogamen-Flora*. The thirty-eighth part of the work, just issued, bringing the supplement well into the Bryums, and thus covering about three-fourths of the original, bears the name of Dr. W. Limpricht in association with his father's. Another part will probably close the final volume.—C. R. B.

O. VON SEEMEN[9] has published an admirable account of the willows of Japan. After a discussion of previous contributions, geographical distribution, and the general principles of classification in the group, the 33 species are presented, 8 of which are new. The descriptions are very full, and the plates leave nothing to be desired.—J. M. C.

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[7] LÉVEILLÉ, H., Monographie du genre Onothera. Le Mans. 1902. Edition 200 copies, price 100 *fr.*

[8] VON SCHRENK, HERMANN, A disease of the white ash caused by *Polyporus fraxinophilus.* U. S. Dept. Agric., Bureau of Plant Industry. Bull. 32. pp. 20. *pls. 5.* Feb. 1903.

[9] SEEMEN, O. VON, Salices Japonicae. pp. vii + 83, *pls. 18.* Leipzig: Gebrüder Borntraeger. 1903. *M* 25.

LIEFERUNG 216 of Engler and Prantl's *Die natürlichen Pflanzenfamilien* is devoted to the conclusion of the treatment of the Orthotrichaceae, to a presentation of the Splachnaceae with 61 species, and of the Funariaceae except the last genus, Funaria. The mosses are now the only group incomplete in this monumental work.—C. R. B.

PROFESSOR ENGLER[10] has published a third edition of his very useful outline of the classification of plants. It will be remembered that this includes the characterization of all families and their important subdivisions; with special mention of useful plants, since the book is intended for the use of pharmaceutical students.—J. M. C.

NOTES FOR STUDENTS.

W. A. WHEELER[11] has published a list of the grasses of Minnesota, based mainly on his redeterminations of the material in the herbarium of the University of Minnesota. The list includes 178 species and varieties, 24 species not having been previously reported from the state.—J. M. C.

NĚMEC[12] reports that the action of benzol and 1 per cent. $CuSO_4$ on the roots of Pisum and Vicia causes many cells to contain two or more nuclei. A few hours later these nuclei are found to have reunited; this fusion of nuclei is obviously not in the least homologous with sexual fusion. The roots eventually die.—E. B. COPELAND.

MELVILLE T. COOK,[13] in investigating *Agrostemma Githago*, finds that the ovulate archesporium consists of one to three cells "of which all but one are absorbed," that a short beak projects through the micropyle, that two or three rows of cells "degenerate" to form a passage for the pollen-tube, that the proembryo is filamentous, later differentiating into a filamentous suspensor with vesicular basal cell and a large spherical embryo.—J. M. C.

CYRIL CROSSLAND[14] has suggested the way in which mangrove seedlings succeed in finding a lodgment on the coast of British and German East Africa, the whole of which is composed of a hard coral limestone. The peculiar seedlings float out to sea in regular fleets, the bud projecting from the water. Upon reaching shore the root-tip is inserted into any softness or crevice of the bottom by the falling tide, and the ripples causing the seedling to oscillate about the tip, it slowly bores down into any mud or crevice.—J. M. C.

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[10] ENGLER, A., Syllabus der Pflanzenfamilien. Edition 3. Berlin: Gebrüder Borntraeger. 1903. *M* 4.

[11] WHEELER, W. A., Catalog of Minnesota grasses. Minn. Bot. Studies **3**: 83–107. 1903.

[12] NĚMEC, B., Ueber ungeschlechtliche Kernschmelzungen. Sitzber. Bohm. Gesells. Wiss. 1902. Repaged reprint, 6 pp.

[13] COOK, MELVILLE THURSTON, The development of the embryo-sac and embryo of *Agrostemma Githago*. Ohio Naturalist **3**: 305–309, *pls. 7, 7a*. 1903.

[14] CROSSLAND, CYRIL, Note on the dispersal of mangrove seedlings. Ann. Botany **17**: 267–270. 1903.

W. C. WORSDELL,[15] using the theory that sporophylls preceded in time all other kinds of leaves, and that the latter have been gradually differentiated from the former by sterilization, has attempted to trace the origin of the flower from such a strobilus as that of the cycads. He calls attention to the fact that in this strobilus the lowest sporophylls are sterile, and claims that these are the progenitors of the floral leaves of angiosperms. He traces the line into the Ranunculaceae, through such forms as Myosurus, and presents a diagram illustrating the origin of calyx and corolla in the family.—J. M. C.

VERY FEW of the Rhodophyceae multiply vegetatively by brood organ or reproductive fragments such as are found in several other groups of thallophytes and among the bryophytes. Okamura,[16] however, reports a clear case in *Chondria crassicaulis* from Japan. Small knob-like branches are formed in the summer, which become richly stored with starch, and ripen in winter, when they are easily detached from the parent plant. Filamentous hold-fasts are developed at the proximal end which doubtless attach the structure when it drifts to a suitable resting place. This habit recalls that of certain Characeae whose nodal regions, stored with starch, may survive an unfavorable season and later produce new growths.—B. M. DAVIS.

MARLOTH[17] has secured some interesting results from a study of Roridula, one of the Droseraceae of South Africa, and the only shrubby member of the family. Roridula with its sticky "tentacles" catches insects to supplement its food-supply, but a spider robs the plant of a share of its prey, being able to walk or run over the leaves without the slightest hindrance from the sticky secretion of the tentacles. At the same time, a small hemipterous insect (capsid) feeds upon the juices of the plant, having likewise acquired immunity from the dangers of the glandular hairs; but the plant utilizes it, by certain attractions in the flower and specially developed mechanical contrivances, to effect cross-pollination.—J. M. C.

A CONTRIBUTION to proteid assimilation in molds is made by W. Butkewitsch,[18] working in the Leipzig laboratory. Aspergillus, Penicillium, and three species of Mucor were grown in solutions of Witt's peptone and of fibrin, and the effect upon the medium was carefully studied. In cultures of Aspergillus most of the modified proteid takes the form of ammonia, while in those of the other molds very little ammonia is produced, decomposition stopping with the amido-acids, especially tyrosin and leucin. The trypsin-like enzyme which produces the last-named bodies is found not only in the cells, but also diffuses out into the medium. Aspergillus possesses the power to break down amido-acids into ammonia, hence the difference between it and the other forms studied.— B. E. LIVINGSTON.

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[15] WORSDELL, W. C., The origin of the perianth of flowers, with special refererence to the Ranunculaceae. New Phytol. **2**:42–48. *pl.* 3. 1903.

[16] Okamura, K., On the vegetative reproduction of *Chondria crassicaulis* Harv. Bot. Mag. Tokyo **17**:1–5. 1903.

[17] MARLOTH, R., Some recent observations on the biology of Roridula. Ann. Botany **17**:151–157. 1903.

[18] BUTKEWITSCH, W., Umwandlung der Eiwessstoffe durch die niederen Pilze im Zusammenhange mit Bedingungen ihrer Entwickelung. Jahrb. Wiss. Bot. **38**:147–240. 1902.

P. and H. SYDOW[19] have commenced a monographic study of the Uredinales which is expected to take three or four years for completion. The work is to appear in fascicles and the first volume is to be devoted to the genus Puccinia. The species of Puccinia are not arranged under their subgenera, Eupuccinia, Heteropuccinia, Brachypuccinia, etc., but according to the families of their phanerogamic hosts. The account has then the effect of a host index elaborated to include descriptions of the parasites. The reason given for this unusual procedure is the impossibility of assigning numerous imperfectly known species to the proper subgenus. One would think, however, that the authors had assumed equally great difficulties because of the confusion which must finally result as specific limits and nomenclature are shifted both among the hosts and parasites. It will be a very useful book, however, if it can be revised at suitable intervals.— B. M. DAVIS.

SOME INTERESTING OBSERVATIONS on the structure and development of young plants of Oedogonium have been recorded by Fritsch.[20] The large disklike holdfast, so characteristic of many species, is by no means universal. There are forms with a rhizoidal base and small point of attachment. Floating plants have a large saclike end which is frequently found in connection with an air bubble, apparently formed by the plant itself. The cap formed at the first cell division of the germinating zoospore is not generally thrown off, although some species have this characteristic habit. The brown deposit, frequently found at the base of young plants, consists of "ferric oxid or of some salt thereof." The colorless condition of Oedogonium filaments probably indicates gradual death of the plant and is not a resting condition, as described by Keller (Proc. Acad. Nat. Sci. Phila. 1901). The paper concludes with an account of abnormal zoospore formation, and some exceptional forms of sporelings.— B. M. DAVIS.

ITEMS OF TAXONOMIC INTEREST are as follows: F. HEYDRICH (Flora **92**: 97-101. *figs. 4.* 1903) has published a new genus (*Rudicularia*) of Valoniaceae from Japan.—H. and P. SYDOW (Ann. Mycologici **1**: 35-36. 1903) have established a new Mexican genus (*Asteroconium*) of Melanconiaceae found on leaves of Litsea.—P. A. DANGEARD (*idem* 61–64) has published a new genus (*Rhabdium*) of Chytridiaceae.—N. L. BRITTON (Torreya **3**:23. 1903) has described a new species of Eleocharis (*E. Smallii*) from Pennsylvania.—F. E. CLEMENTS (Bull. Torr. Bot. Club **30**:83–94. 1903) in describing new Ascomycetes from Colorado has published *Tichosporium*, *Psilothecium*, *Ophiogloea*, *Scytopezis*, and *Heteroplegma* as new genera.—C. H. PECK (*idem* 95–101) has published a new fungous genus (*Mitruliopsis*) related to Mitrula.—A. HOLLICK (*idem* 102–105) has described a new Magnolia and a new Ficus from the Cretaceous of Kansas.—W. W. ROWLEE (*idem* 106–108) has described a new pine (*P. recurvata*) from the Isle of Pines.—W. A. MURRILL (*idem* 109–120) in his second paper on the Polyporaceae of North America presents Pyropolyporus, recognizing 18 species, 10 of which are new.—C. S. SARGENT (*Rhodora* **5**:52–66. 1903) has published 13 new species of Crataegus recently recognized in eastern Canada and New England.—B. L. ROBINSON (*Rhodora* **5**:85–89. 1903) has shown that *Echinodorus parvulus* is not to be regarded as an Alisma.—M. L. FERNALD (*idem* 90–92) has described a new Bidens (*B. Eatoni*) from Massachusetts.—P. HENNINGS (Hedwigia Beibl. **42**:22–24. *figs. 5.* 1903) has described a new genus (*Ruhlandiella*) of Rhizinaceae from Germany.—J. M. C.

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[19] SYDOW, P. and H., Monographia Uredinearum. Vol. I, fasc. 1 and 2. *pls. 25.* Leipzig: Gebrüder Borntraeger. 1902. Each *M* 12.

[20] FRITSCH, F. E., The structure and development of the young plants in Oedogonium. Annals of Botany **16**: 467-486. *figs. 3.* 1902.

RECENT TERATOLOGICAL LITERATURE.—In the American Florist **19**:866, 1902, are two excellent figures of torsion in the stem of carnations.—DRUERY (Gard. Chron. **32**:226–228. *figs. 77–78.* 1902) records a cristate variety of *Pteris aquilina* growing spontaneously, and illustrates it by two photographs.—FLOYD (Rhodora **4**:244–245. 1902) notes the discovery of a cristate form of *Nephrodium marginale*, and since the variation seems to be permanent proposes *N. marginale* forma *Davenportii*. The fixation of cristation in ferns is well known.—BOWER (Ann. Botany **17**:278–280. 1903) figures and describes an abnormal specimen of *Lycopodium rigidum* Gmel. in which a sporophyll of slightly greater width than the average subtends two sporangia of slightly unequal size, and calls attention to the rarity of such variations in the Lycopodiaceae.—RAYMONDAND (Rev. Sci. du Limouscin **10**:370–373. *pl. 3.* 1902) describes and figures syncarpy in the bean (*Phaseolus vulgaris*), and discusses at considerable length the question of the terminology which should be employed in such cases. The paper might give the impression of greater value had the author mentioned at least two or three of about fifteen descriptions which have been published of syncarpy in this species.—BRITCHER (Bull. Maine Agric. Exp. Station no. 86. 1902) discusses variation in *Trillium grandiflorum* Salisb., giving many tables of measurements and six plates from photographs of normal and abnormal forms.—Under the title "Petiolate connation in *Trifolium pratense*" WHITE describes (Torreya **2**:183–184. 1902) abnormal leaves of *T. pratense* consisting of five and six leaflets on unusually strong petioles, and concludes that the examples represent cases of connation rather than the production of supernumerary leaflets.—Fasciation in *Lilium Henryi* is figured and described by HENRY

Garden **62**: 284. 1902). From the ground the stalk is almost flat, reaching a width of eight and one half inches at the top, with a thickness of only a quarter of an inch. The total length of the inflorescence is twenty-one inches and the total height of the plant seven feet and five inches.—" L." (Meehan's Monthly **12**: 152. 1902) records a specimen of *Lilium superbum* with four rows of petals. Three of the stamens had been transformed and the other three had distorted anthers. The editor comments on the observation and refers to a case in the tiger lily.—TROTTIER (Bull. Soc. Bot. Italiana **1902**: 44–50. *fig.*), in addition to bringing together a number of examples of teratological phenomena which are to be attributed to parasitic influence, presents some miscellaneous observations, noting the occurrence of a hypertrophy or fasciation in the male catkin of *Alnus glutinosa* Gaertn., fasciation of the stem in *Chrysanthemum Leucanthemum* L., fasciation and some accompanying malformations in *Euphorbia Cyparissias* L., abnormal leaves in *Fagus silvatica* L., floral proliferation, stasimorphy, and fasciation in *Galega officinalis* L., fasciation in *Passiflora coerulea* L., torsion of the stem in *Ranunculus acer* L., and formation of foliar ascidia in *Ulmus campestris* L. —FOCKEU (Rev. Gén. Bot. **14**: 517–521. *figs. 61–63.* 1902) describes floral monstrosities in *Digitalis purpurea* L. The abnormal flowers occupy the terminal portion of the inflorescence and are divided by him into three classes according to complexity of structure. The malformation, he concludes, is due to the growing together of two or more flowers. Abnormalities in the flowers of this species are especially well known and it seems hardly probable that the paper contains any forms which have not been noted in the very numerous papers, about twenty-five in number, which have touched on this point. It is unfortunate that some of the literature was not available to Fockeu.—CUSHMAN has recently published a paper (Amer. Nat. **36**: 865–885. *pls. 1–5.* 1902) in which he discusses and figures some of the abnormal forms of leaves in the adult plants and compares them with the seedlings of the following species: *Viola pedata* L., *Chelidonium majus* L., *Ranunculus acris* L., *Spiraea salicifolia* L., *Tanacetum vulgare* L., *Viola tricolor* L., and *Rosa rubiginosa* L. He assumes that these "localized stages" represent the form of ancestral types, and that with a knowledge of seedlings and ancestral forms, these "localized stages" may be used to great advantage in determining the phylogeny and relationships of the plant. As to whether deviations from the normal structure of the kind described in the present paper belong to teratology or not depends, very evidently, upon the way in which this very differently defined term is limited.—A paper of a type which is rare in these days, since it is an extensive paper on the abnormalities of plants, and of a type which is rare in the literature of teratology, in that it is a monographic treatment of a definitely limited field, is that of STENZEL (Bibliotheca Botanica **55**: 1–136. *pls. 1–6.* 1902). In an introduction of twenty-eight quarto pages, the first section is devoted to a consideration of the value of the deviations from the normal structure. In this section he reviews the widely differing opinions which have been held since the time of Goethe, and illustrates the present and past valuation of teratological observations as data for morphological conclusions by a review of the work which has been done in the Abietineae. Here he admits freely the importance of embryogeny in the solution of questions in morphology, but also calls attention to some of the conclusions which have been reached by the recognized leaders in embryology, and suggests that it would be interesting to compare, both as to number and importance, the erroneous conclusions which have been drawn from embryological evidence with those which are to be attributed to the "Irrwege der Missbildungslogik." He expresses his own belief in the value of teratological evidence in the solution of morphological questions. Over one hundred pages are then devoted to the floral abnormalities, arranged according to the nature of the malformation, which have been observed in native orchids growing in the open. A discussion of the different types of abnormalities observed is not possible in this place, and of their value only the specialist can judge, but the mass of observations and references to literature will surely be of great value. The paper is illustrated by six lithographic plates.—J. ARTHUR HARRIS.

NEWS.

HENRY HOLT AND COMPANY announce that "a plant physiology," by Professor George J. Pierce, will be issued in the spring.

M. G. ROUY has begun the publication of a monthly *Revue de Botanique Systématique et de Géographie Botanique*, to be edited by himself.

PROFESSOR L. H. BAILEY has been appointed director of the college of agriculture and dean of the faculty of agriculture of Cornell University.

M. MILLARDET, formerly professor of botany at Bordeaux, who did much to restore the French vineyards after their destruction by phylloxera, died December 15 at the age of 64.

WE learn from *Science* that at Barnard College, Columbia University, Dr. H. M. Richards and Miss Margaret E. Maltby have been promoted to adjunct professorships of botany.

DR. G. R. WIELAND, of the Yale University Museum, has received a grant of $1,500 from the Carnegie Institution for the continuation of his researches on the structure of fossil cycads.

DR. J. B. OVERTON, professor of biology in Illinois College, has been appointed research assistant by the Carnegie Institution, and will spend a year at the Botanical Institute of the University of Bonn, at the instance of Professor Strasburger, to carry on researches under his direction.

THE FIRST CIRCULAR in reference to the International Botanical Congress to be held in Vienna in 1905 has been issued. It contains a complete list of the Committee of Organization, and also announces that the congress will be held June 12–18, 1905. All correspondence in reference to it should be addressed to Dr. A. Zahlbruckner, Vienna, I., Burgring 7.

DR. FREDERICK D. HEALD has been elected adjunct professor of plant physiology and general bacteriology in the University of Nebraska. He is to develop the work, begun last year, in general bacteriology, and to oversee the laboratory work in plant physiology. Dr. Heald is to begin his new work in the summer, taking charge of the classes in botany in the summer session.

ERRATA.—In the article by Professor Bruce Fink in the March number the editors are responsible for the transposition of the cuts on pages 203 and 205. The inapplicability of the legends will render the mistake obvious. The author wishes to repair his failure by now making grateful acknowledgment of his indebtedness to Mr. C. J. Hibbard, of Minneapolis, for the photographs from which illustrations were made.

THE OHIO State University has organized a lake laboratory, located at Sandusky Bay. A new building capable of accommodating 100 students and investigators will be erected in time for the summer session, which commences June 29 and closes August 7. The laboratory will be open longer to those who desire to continue their work. Twenty-four were enrolled last summer. The location offers varied conditions of open lake, bay, marsh, river, native forest, sandy beach, and rocky islands. The laboratory is supplied with boats, dredges, seines, etc. The extensive fishing industry of Sandusky, and the U. S. Fish Hatchery at Put-in-Bay give additional advantages. The botanical staff includes Professor W. A. Kellerman, Columbus, Ohio (to whom inquiries may be addressed), Professor J. H. Schaffner, and Mr. E. O. Jennings.

THE SIXTEENTH SESSION of the *Marine Biological Laboratory* at Woods Hole will extend from July 1 to August 12, 1903. The botanical staff, headed by Professor Bradley M. Davis, comprises nine members, representing seven institutions. There will be given an instructional course of lectures on thallophytes, with laboratory work; a course on general physiology for investigators; a series on plant hybridization and breeding; and a series of general lectures by members of the staff, investigators, and guests. The advantages of Woods Hole for botanical study are too well known to need restatement. The Carnegie Institution controls a number of research tables, which will be assigned to suitable applicants, and the laboratory provides others. All are free of expense. Information may be obtained from Professor B. M. Davis, The University of Chicago.

THE MICHIGAN Academy of Science met at Ann Arbor, March 26–28. Professor F. C. Newcombe was vice-president of the section of botany, whose program was as follows: The effect of dilute and concentrated sea water on Cladophora, S. O. MAST; The osmotic relations of algae to their environment, HOWARD S. REED; Protoplasmic movement in *Elodea canadensis*, RENA B. RAYMOND; Structural variations of Chara, ELLEN B. BACH; The latent period in traumatropism, GEORGE P. BURNS; Extent of the sensory zone for heliotropism of terrestrial roots, DARRELL H. DAVIS; Final demonstrations of thigmotropism in terrestrial roots, FREDERICK C. NEWCOMBE; On the absorption of water by foliage leaves, including a history of the subject, J. B. DANDENO; Notes on Michigan fungi, including some new species of Hymenomycetes, B. O. LONGYEAR; The lichen genus Physcia, E. E. BOGUE; Some interesting hybrid oaks in the vicinity of Ann Arbor, CHARLES A. DAVIS; Preliminary account of the distribution of *Quercus imbricaria* in Washtenaw County, CHARLES A. DAVIS; The geographic distribution of bog plants, E. N. TRANSEAU; The succession of plant societies in Ypsilanti and Augusta townships of Washtenaw county, FOREST B. H. BROWN; The new Michigan oak, *Quercus Alexanderi* Britt.; its characteristics and distribution, S. ALEXANDER.

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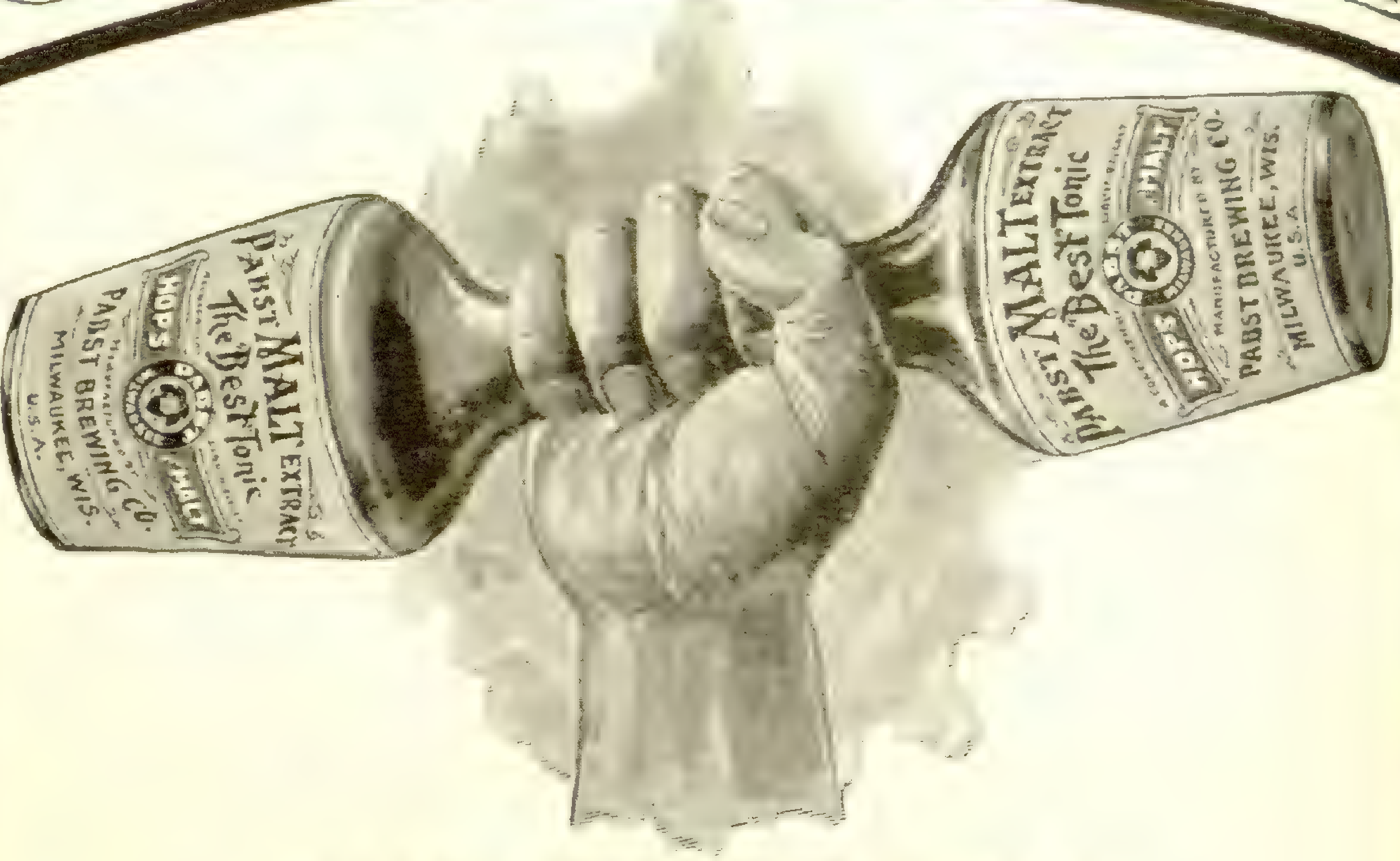
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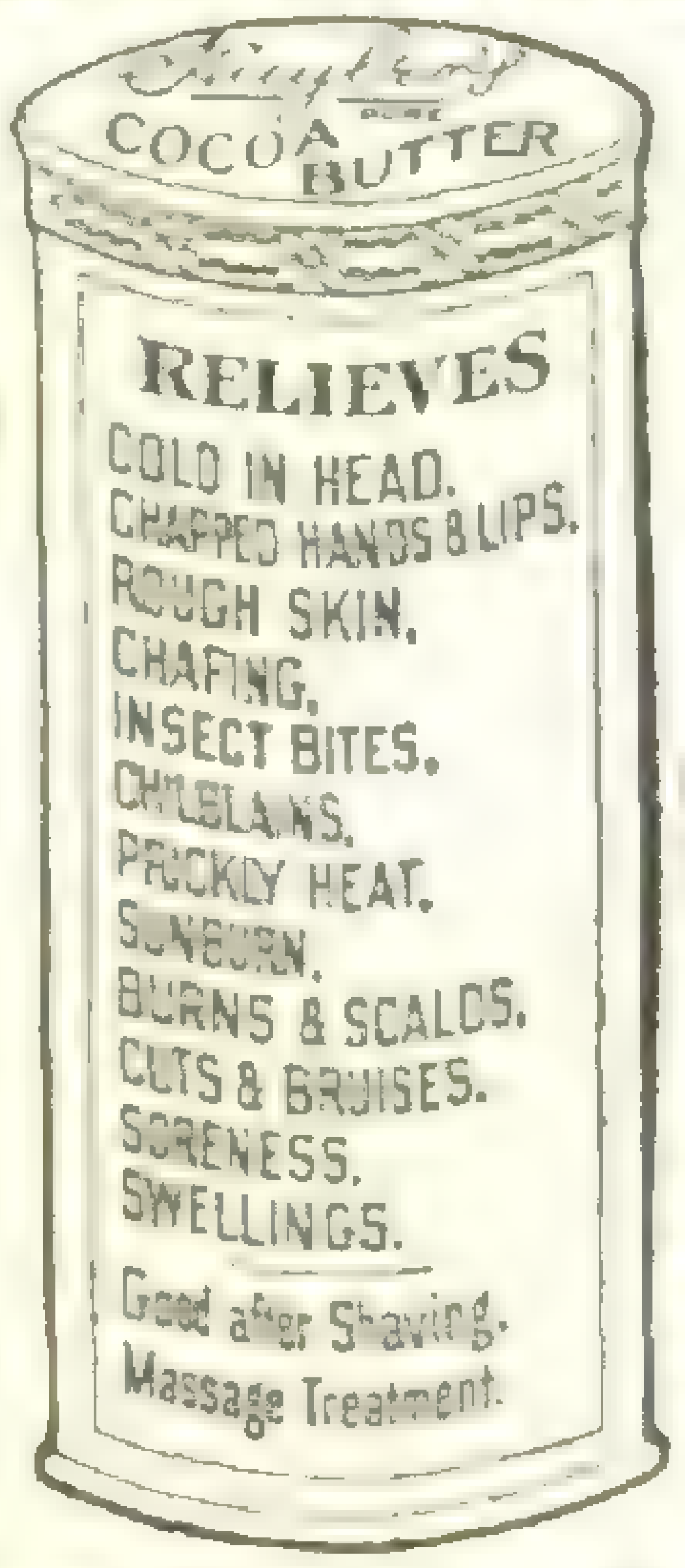
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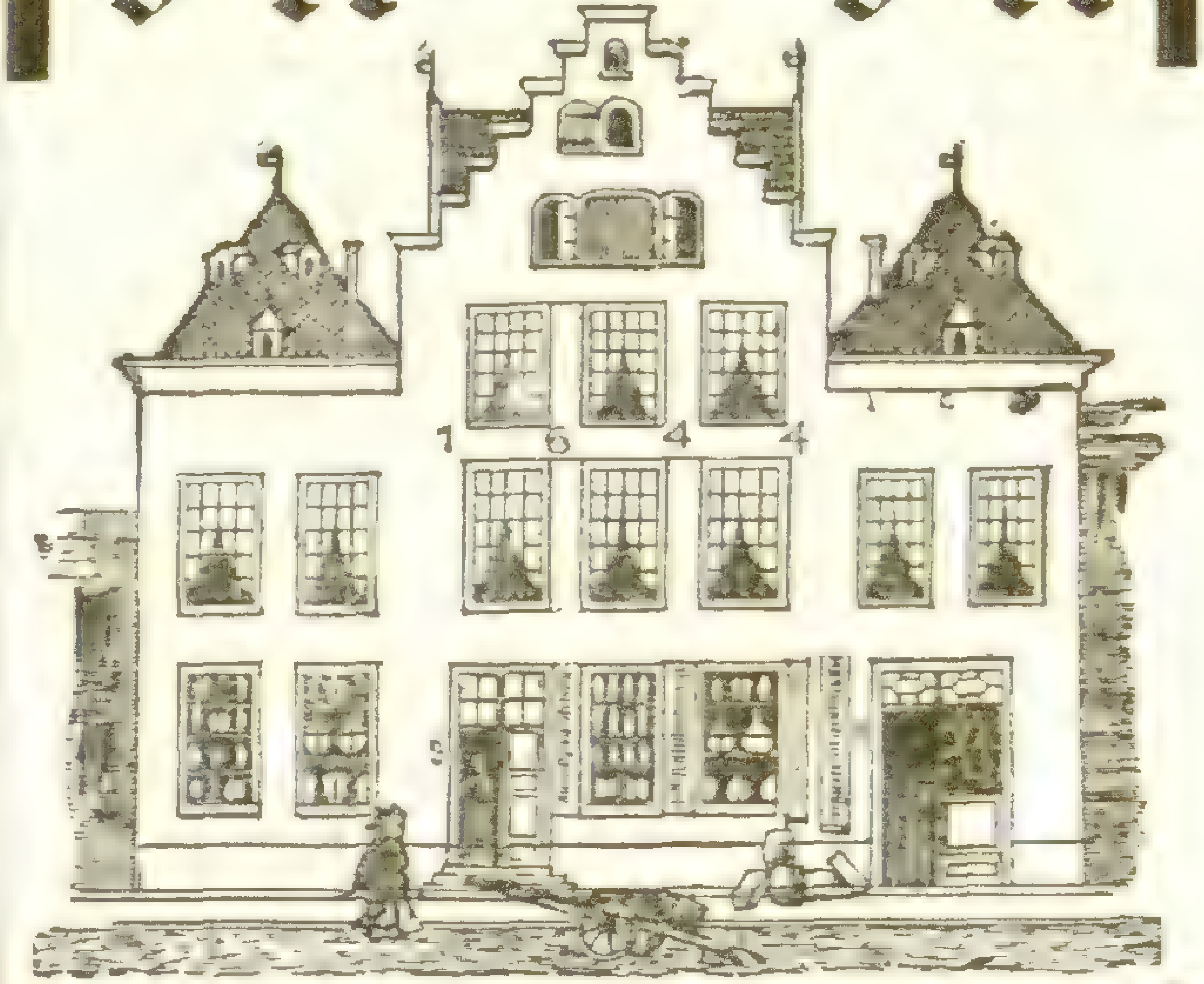

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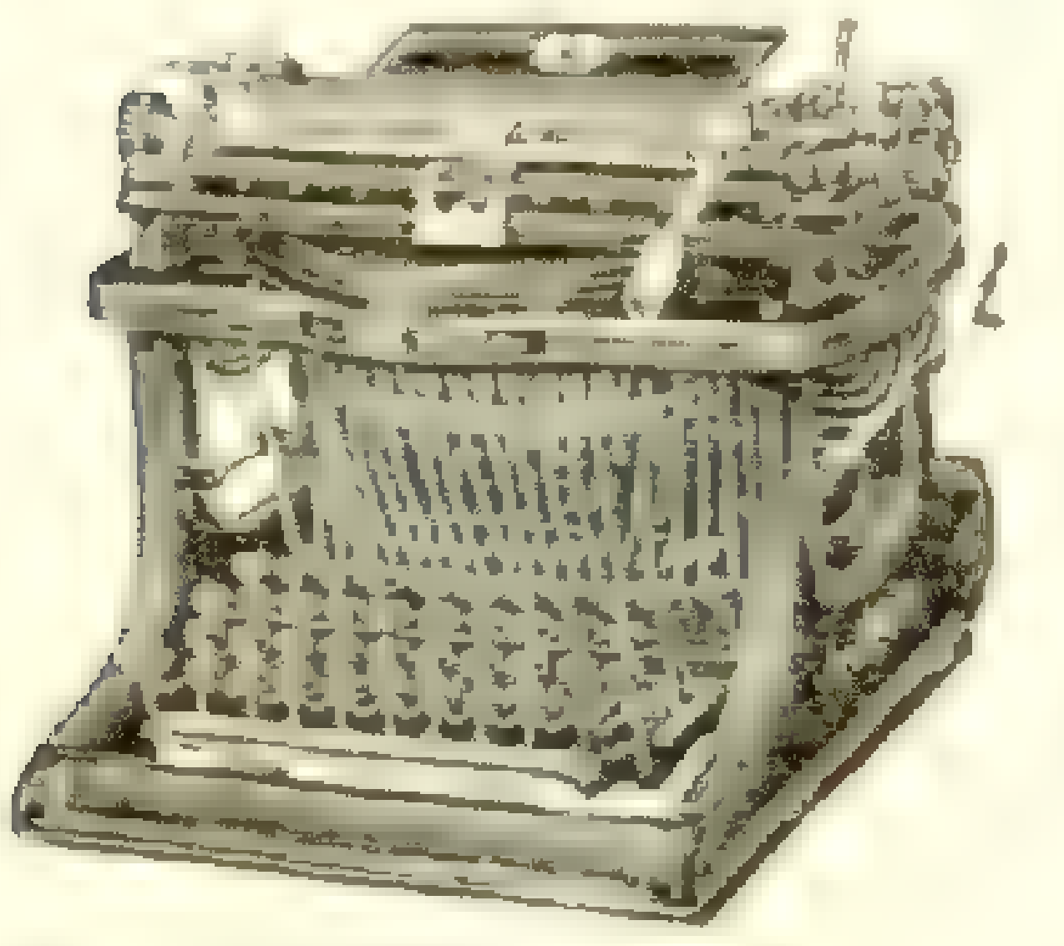

SOME FACTS ABOUT TYPEWRITERS

Great progress has been made in building typewriters in the last three years, greater advances than in all the time previous. Years of experience have shown what was valuable and desirable and what should be sacrificed. Some typewriters do good work and are durable, yet are hard to operate and are cumbersome; others are too complicated and easily get out of order, do not keep alignment, etc.

Operators who have used **THE FOX TYPEWRITER** are unanimous in agreeing that it combines more desirable features than any writing machine yet produced. It is a basket type machine, with ball bearing carriage, two oz. key tension, half-inch key dip, aluminum finger levers with individual tension, adjustable type-bars—insuring perfect alignment, even after years of service, line lock, automatic line spacer, and automatic ribbon movement, combining the features that give durability with the lightest touch, easiest action, and most simple construction.

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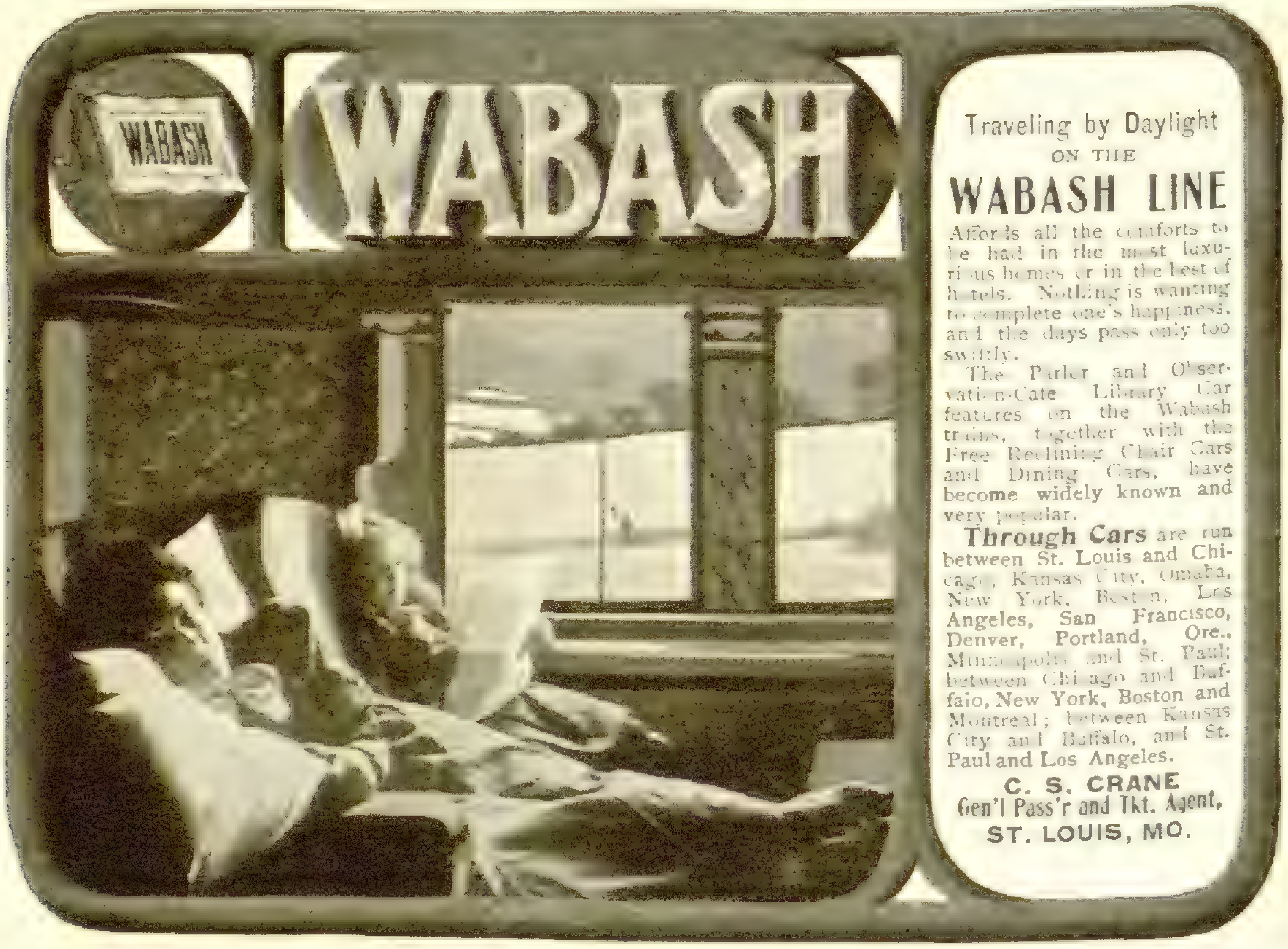

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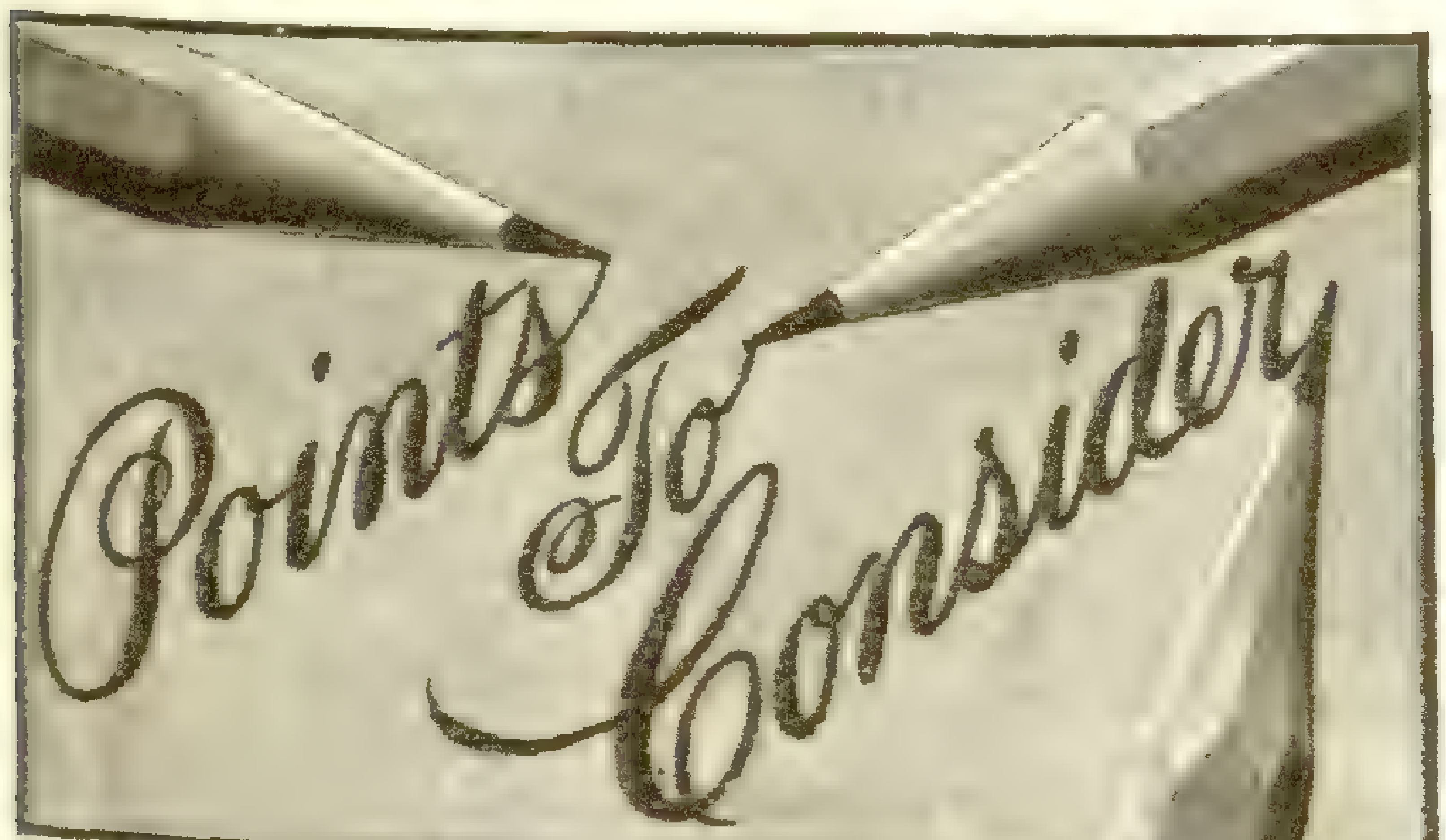

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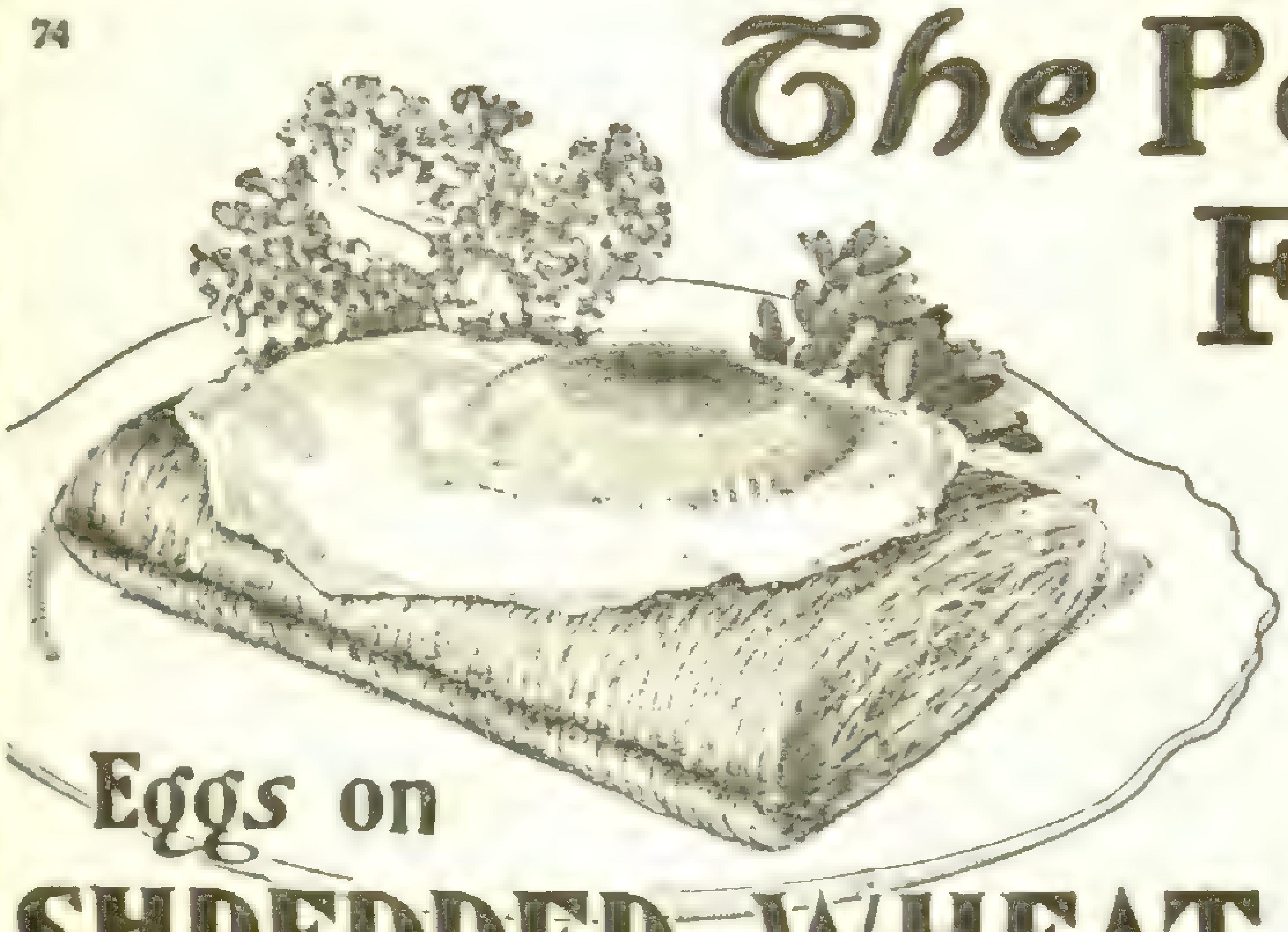

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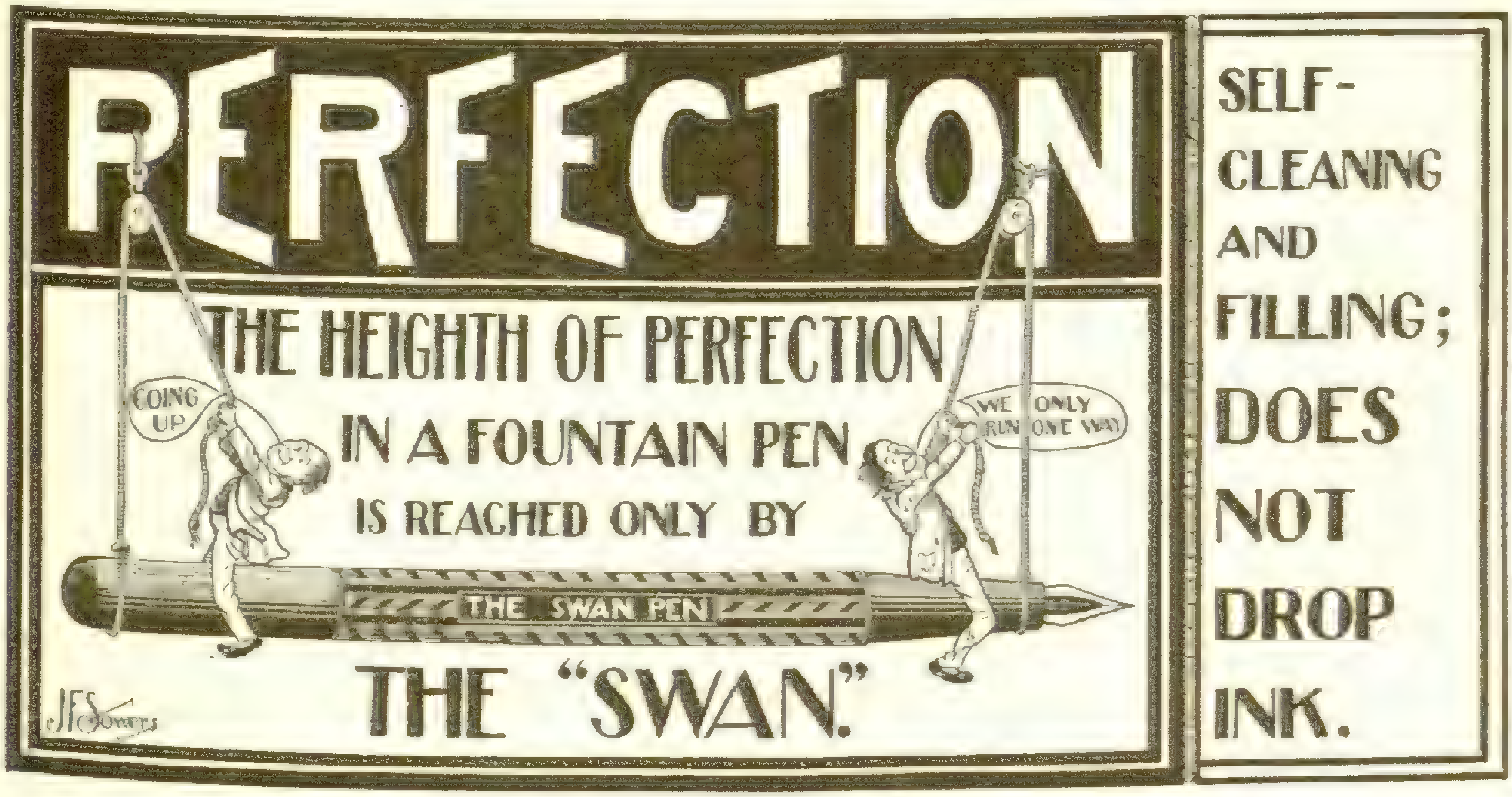

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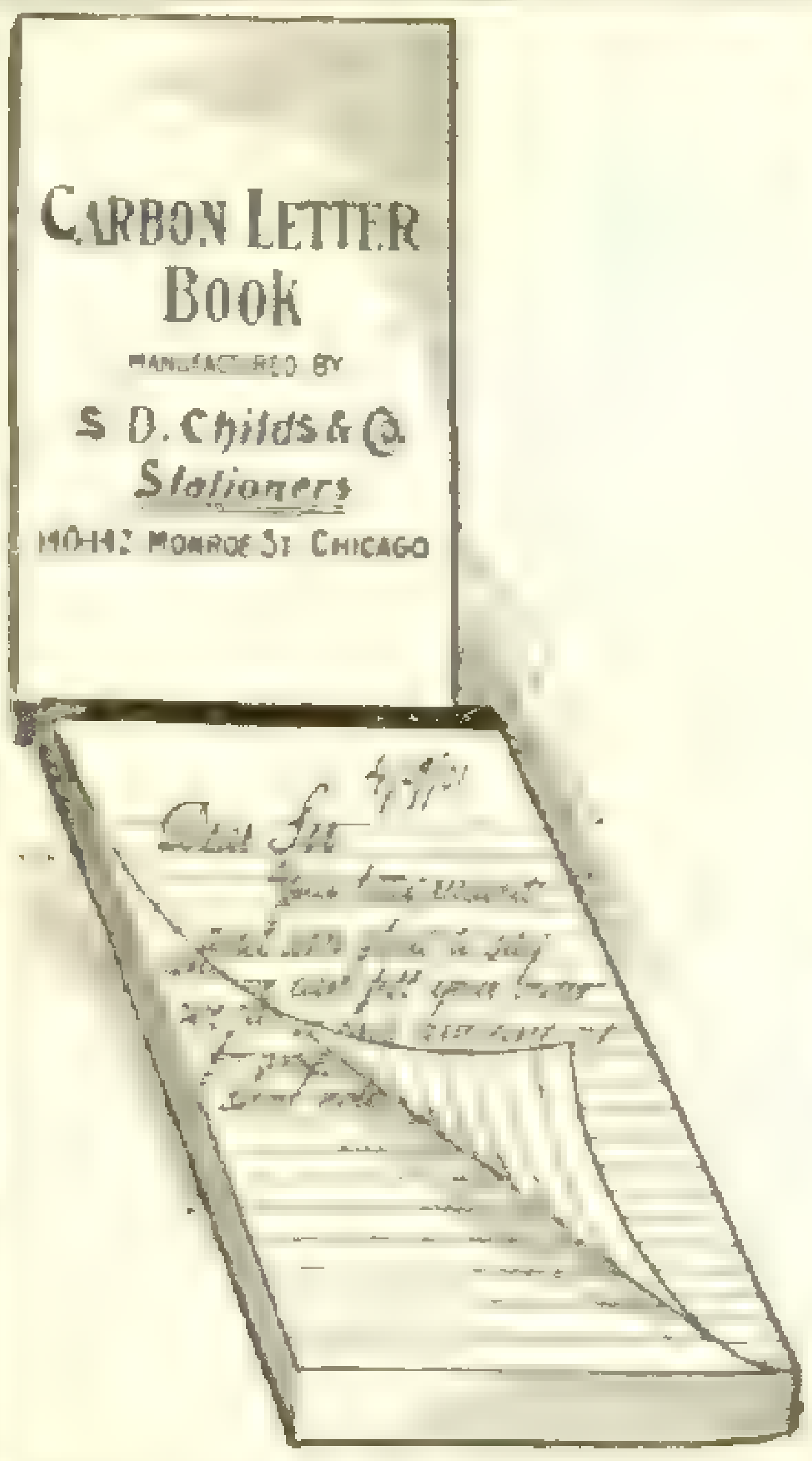
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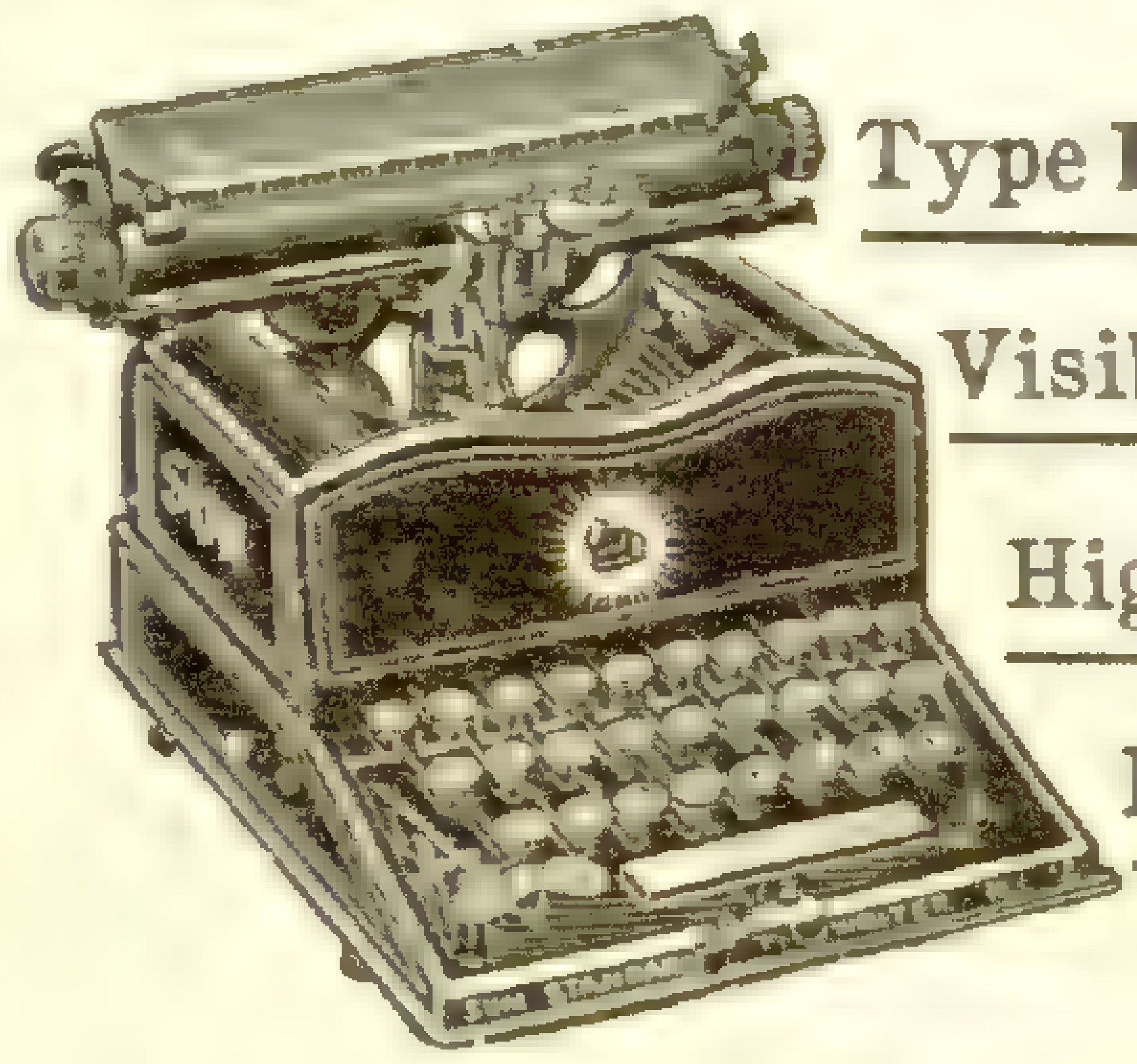

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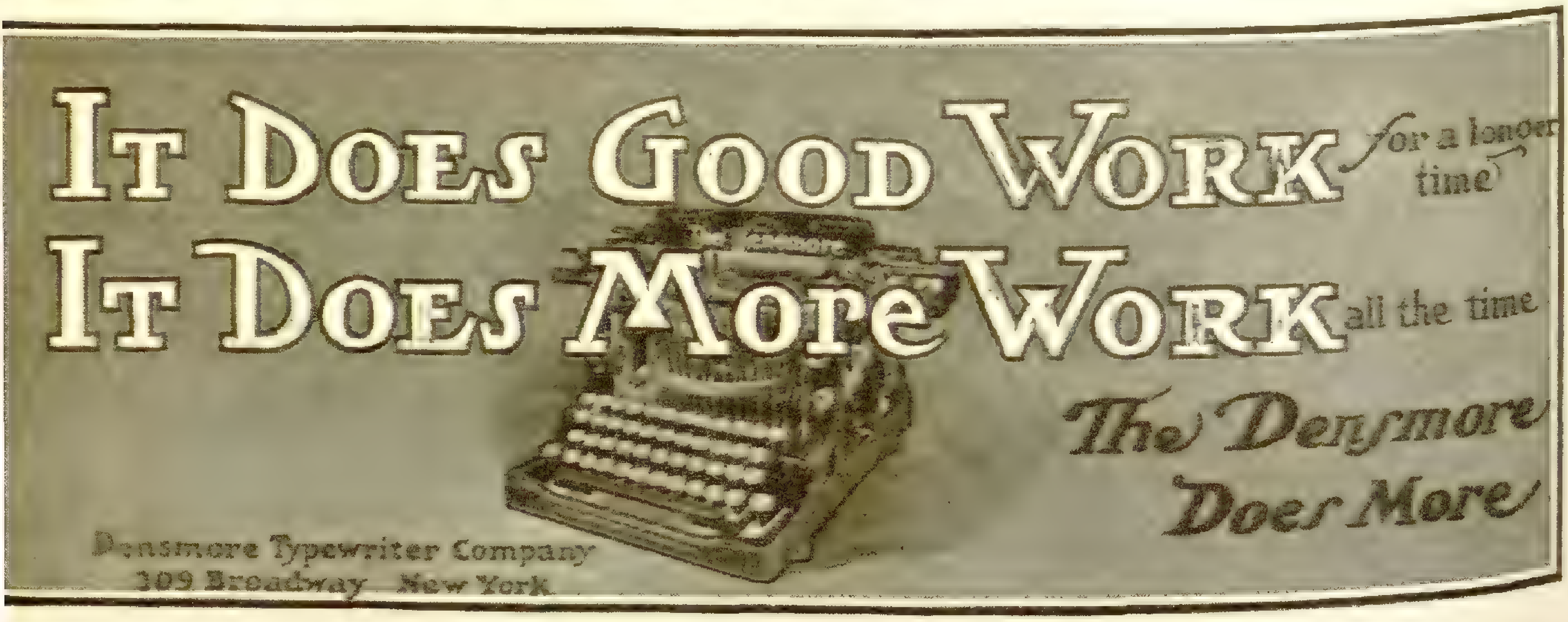
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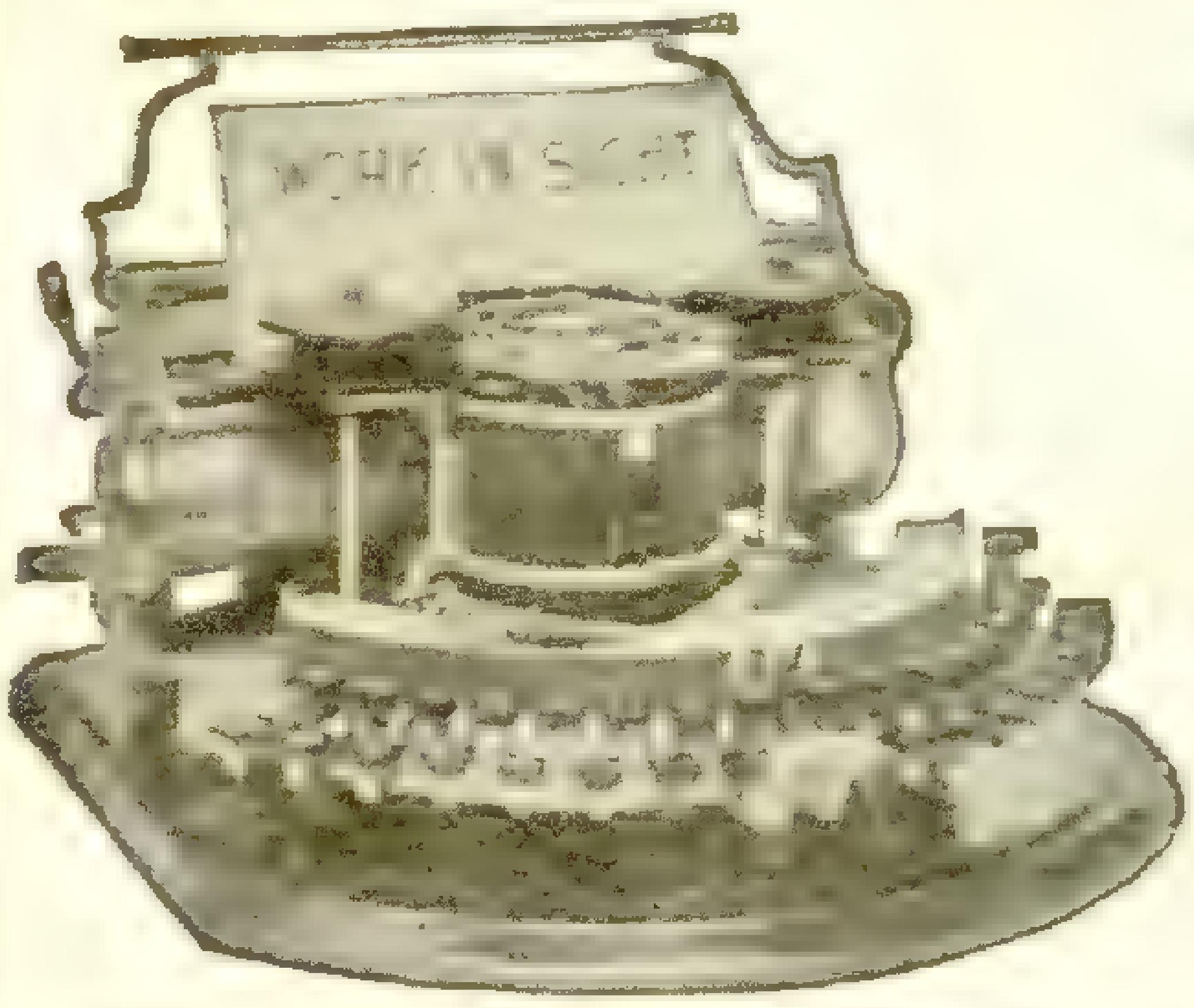

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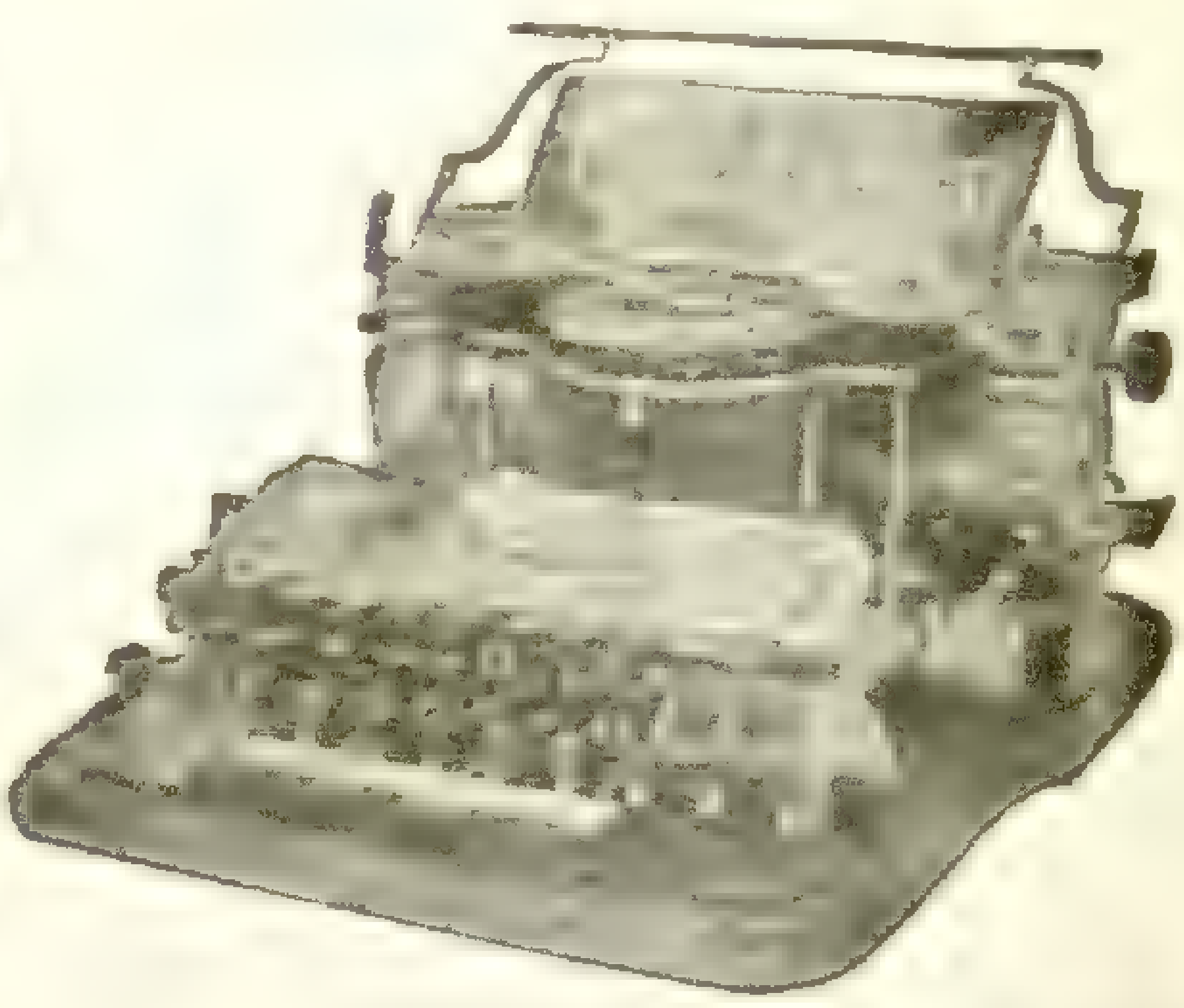

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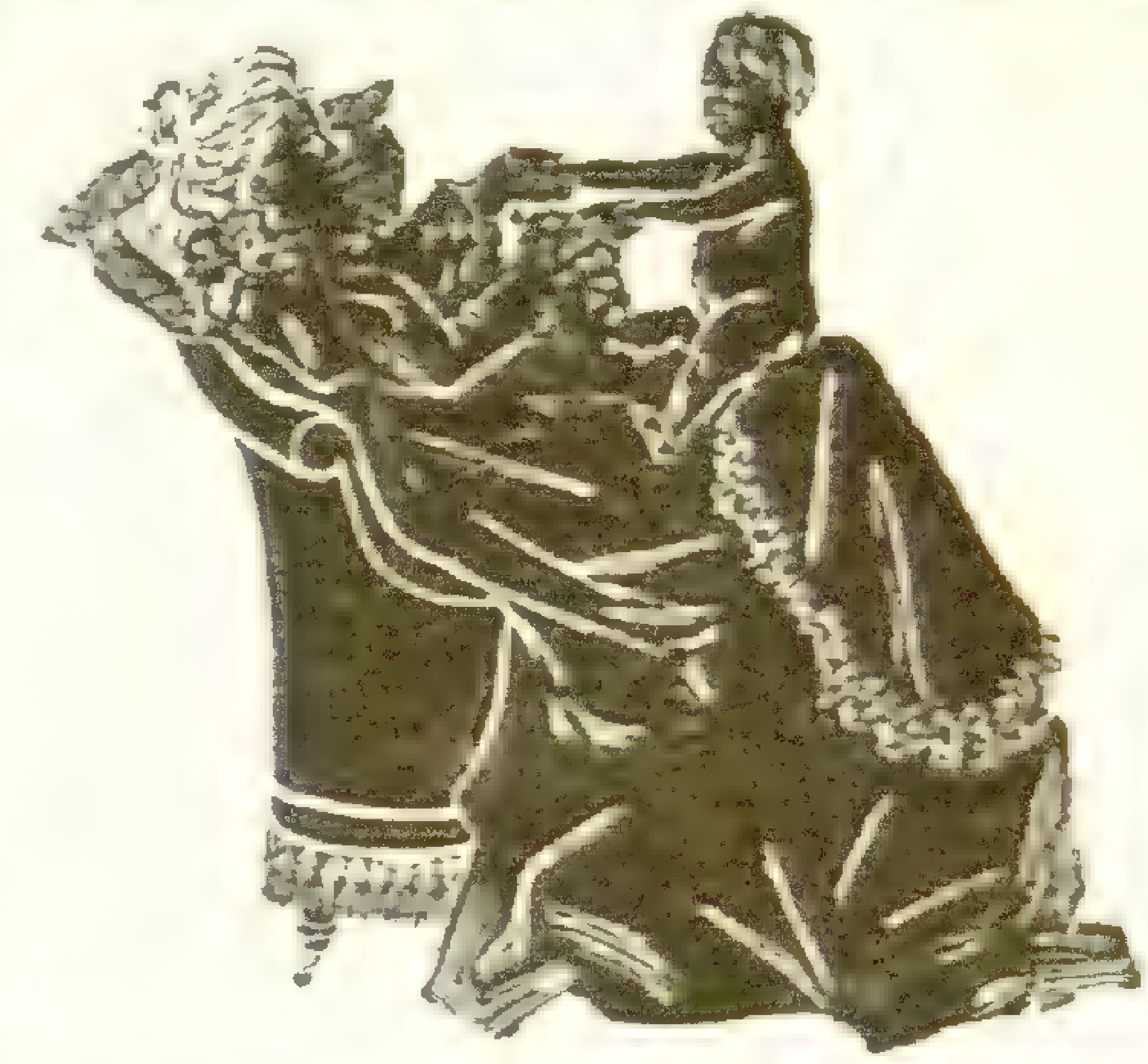

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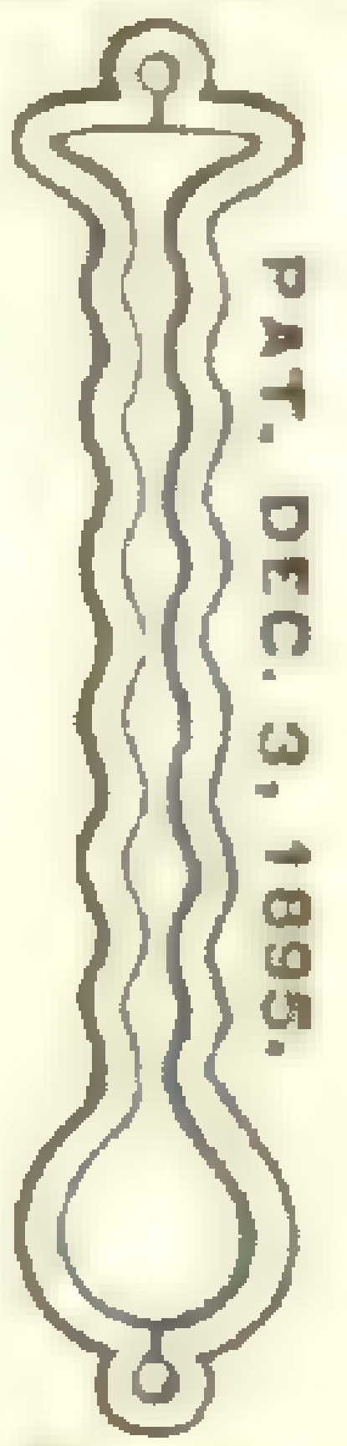
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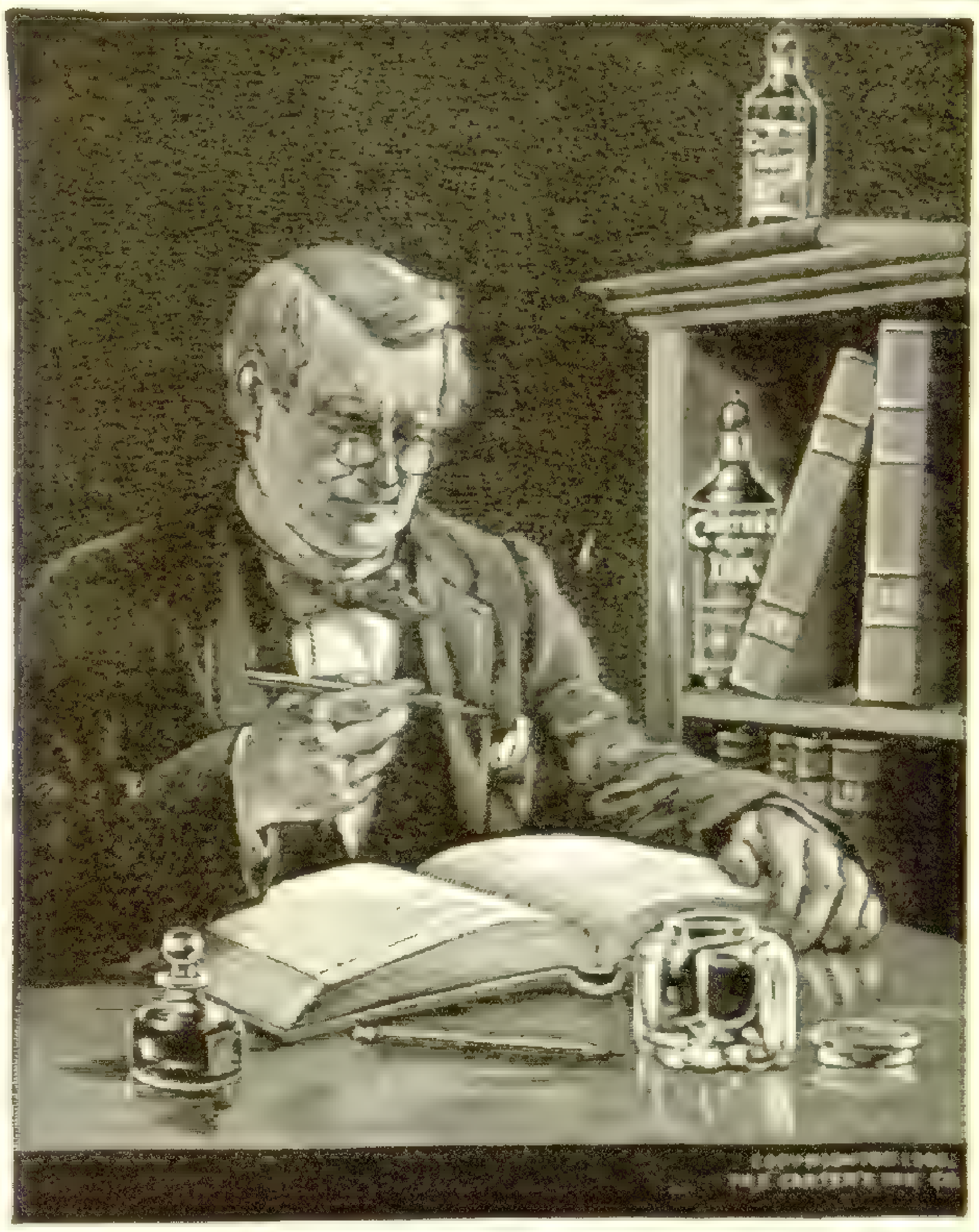

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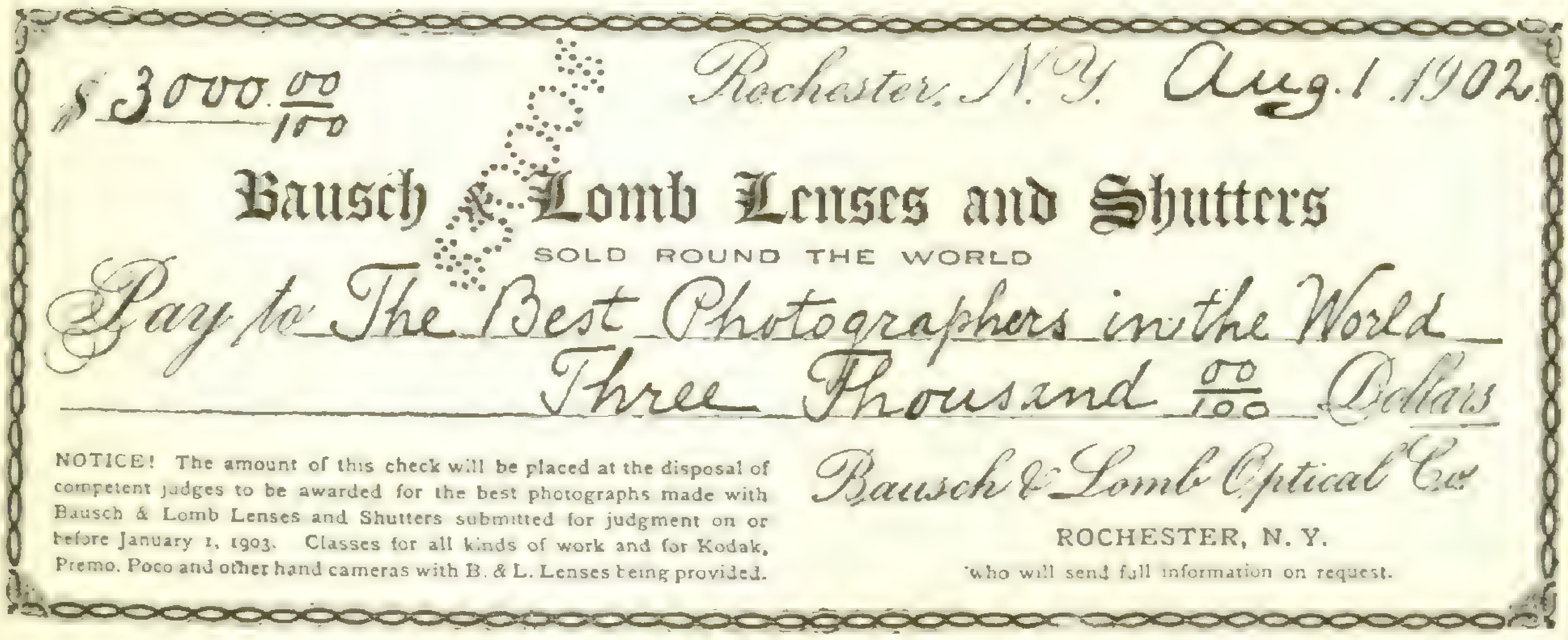

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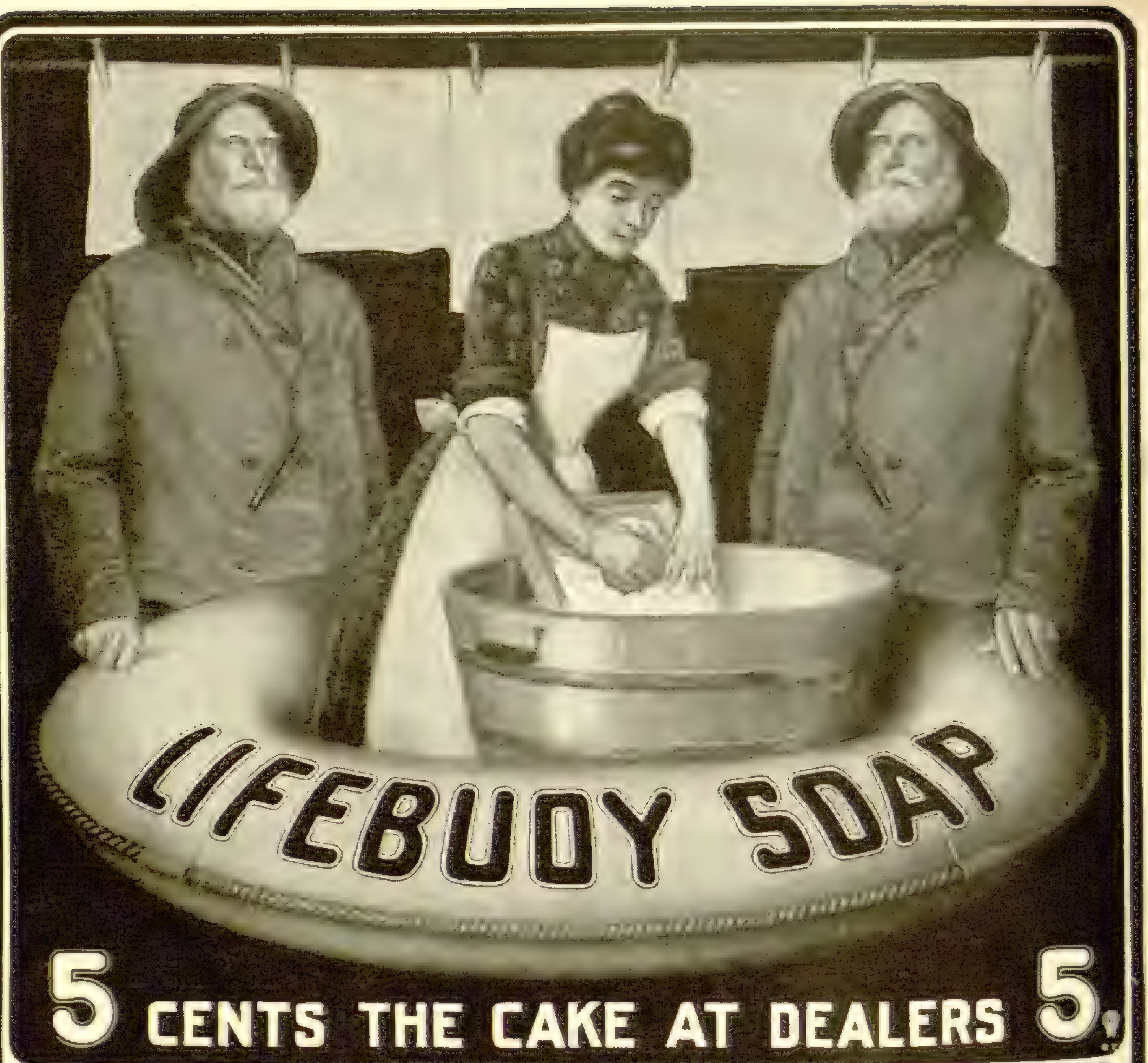
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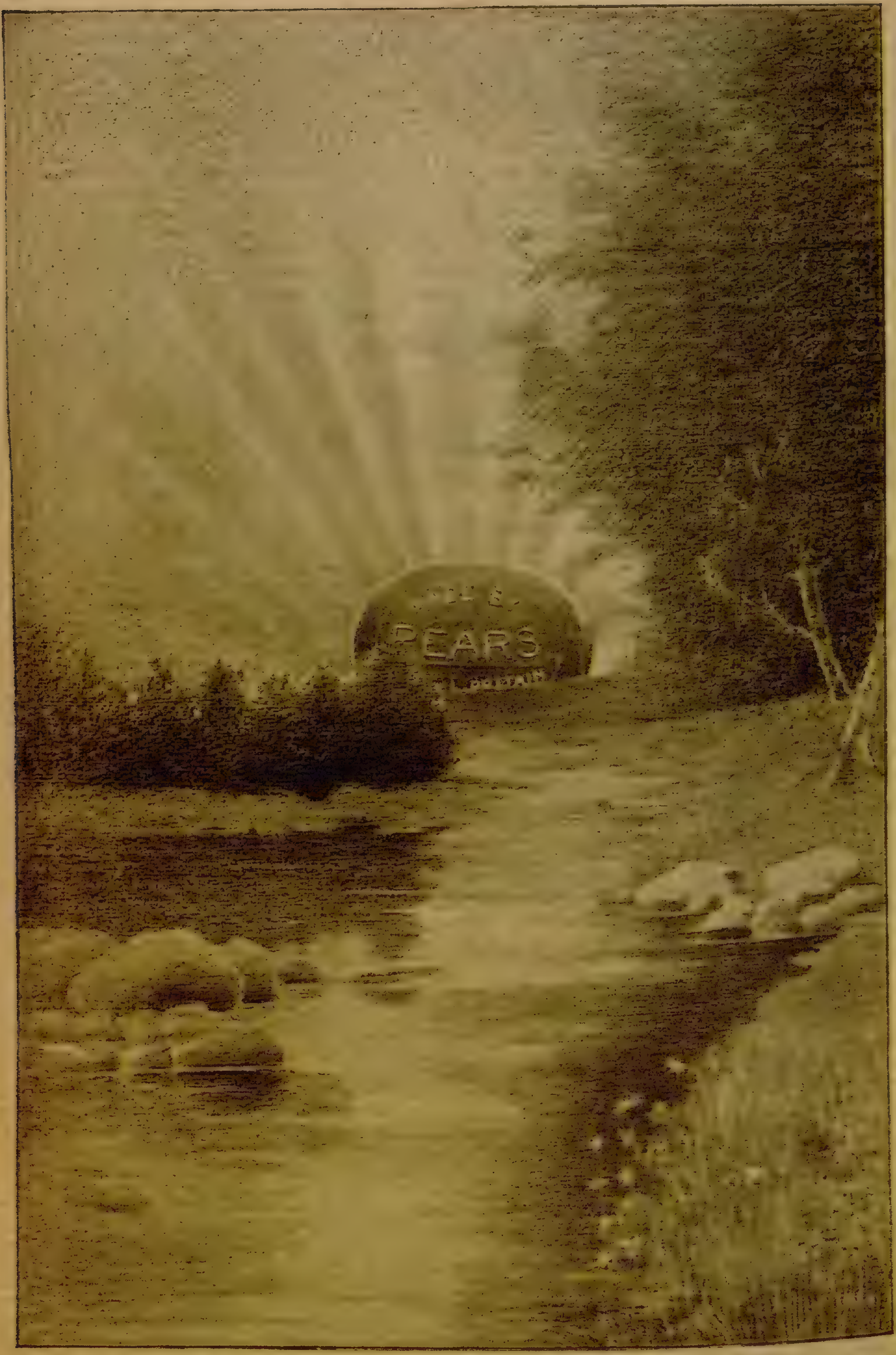

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VOLUME XXXV NUMBER 5

BOTANICAL GAZETTE

MAY, 1903

ON THE RELATIONSHIP OF THE NUCLEAR MEMBRANE TO THE PROTOPLAST.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XLVII.

ANSTRUTHER A. LAWSON.

(WITH PLATE XV)

THE nucleus has long been regarded as not only the most important, but with its chromatin, linin, nucleolus, karyolymph, and membrane, it is also regarded as the most complex organ of the cell. Although the literature on plant cytology is rapidly accumulating and revealing much that is of interest on the centrosome question, spindle formation, chromosome reduction, etc., we as yet know little or nothing as to the origin and development of the nucleus. Its morphology is hidden by its complexity. This apparent complexity of the nucleus is in a large measure due to the presence of the nuclear membrane. A nucleus without a membrane, as we see it in certain stages of mitosis, becomes a comparatively simple structure. Such a condition of the nucleus may be observed immediately preceding spindle formation in the spore mother cells of any of the higher plants. At this stage the nuclear wall disappears, the karyolymph becomes diffused throughout the cytoplasm, the nucleolus and the linin lose their identity, and the only element left which can be regarded as nuclear is the mass of chromatin. It thus becomes evident that the formation of a membrane is the most important factor which gives the nucleus its complex structure.

So far as the writer is aware, no observations have been recorded on the origin and formation of the nuclear membrane in plants. It is the object of the present work, therefore, to account for the presence of this membrane and its morphological relationship to the other nuclear elements, with the hope that it might lead to at least a partial understanding of the morphology of the nucleus itself.

In undertaking this work it was at first thought that a study of the most primitive types of plant life—where the cell is much simpler and the nuclear structures less highly differentiated than in the higher types—would be the most natural way of approaching the subject. Consequently the cell contents of a large number of forms of the Cyanophyceae and of the simpler Chlorophyceae were examined. A careful study of these forms, however, failed to give satisfactory results so far as the formation of the nuclear membrane is concerned. In the cell of the Cyanophyceae bodies were found which resembled chromatin, but in none of the forms examined could any of the other nuclear structures be identified. These chromatin-like bodies were surrounded by neither nuclear sap nor membrane. In the simpler Chlorophyceae examined the chromatin was found to be surrounded by both nuclear sap and membrane, but the nucleus was found to be much too small to follow out accurately the stages in the formation of the nuclear membrane. It has been thought advisable, therefore, to use the highly organized nucleus of the flowering plants as an object for this study. The following conclusions, therefore, are drawn mainly from observations made in the individual history of the typical nucleus of the higher plants.

MATERIAL AND METHODS.

In order to follow the sequence of events which lead to the formation of the nuclear membrane, it is desirable to obtain material with clear large nuclei, where the various stages in the development of the daughter nuclei may be distinctly observed. For this purpose the sporogenous cells of the higher plants seemed to furnish all the desired conditions.

Although the spore mother cells of *Passiflora coerulea* and the archesporial cells of *Equisetum limosum* were especially studied, and were selected as types to illustrate the process of nuclear membrane-formation, the results obtained from these forms were confirmed by observations made on several other forms, such as Lilium, Cobaea, Gladiolus, Hedera, Pinus, Pteris, etc.

Flemming's strong solution of chromic-osmic-acetic acid, diluted with one volume of water, was used for fixing, and the triple stain, safranin, gentian-violet, and orange G, for staining. After being fixed the material was washed in running water and was then dehydrated by being passed through various grades of alcohol. Bergamot oil preceded the infiltration of paraffin. Microtome sections from 1 to 3.6μ thick were used.

THE FORMATION OF VACUOLES AND THEIR RESEMBLANCE TO NUCLEI.

To any one who has made a special study of the nucleus, especially of the spore mother cells of the higher plants, the resemblance of this body to a vacuole has probably suggested itself. As is well known, the presence of a vacuole is one of the most striking characteristics of the plant cell. This is particularly so of the mature cells in any vegetative tissue, where the vacuole is quite as constant as the nucleus. The vacuole is not apparent in the very young cell, as the nucleus and cytoplasm seem to occupy the entire cell cavity. At an early stage in the growth of the cell, however, small lacunae containing a watery fluid may be observed in the cytoplasm. As the cell continues to grow these lacunae become much larger and finally flow together, forming one or more large vacuoles in the cell. As these vacuoles enlarge the cell continues its growth. The amount of cytoplasm, however, does not increase at the same rate as the contents of the vacuole. The result is that in the mature cell the vacuole may occupy the greater part of the cell cavity. The watery fluid of the vacuole holds many substances in solution. It may function as a storehouse for reserve food material. It may even contain solid bodies such as starch grains, aleurone grains, and crystals of calcium carbonate or oxalate. Finally the vacuole is always surrounded by a distinct limiting plasmatic membrane.

In all of these particulars the structure of the mature nucleus bears a very striking resemblance to the vacuole. It is a cavity containing a watery fluid—the nuclear sap or karyolymph—in which lie imbedded the chromatin thread and nucleoli. Structurally the nuclear sap may be compared to the cell sap of the vacuole; the chromatin and nucleoli may be compared to the solid bodies of reserve food materials found in the cell sap; and finally the nuclear membrane may be compared to the tonoplast. These two latter structures not only bear a general resemblance to each other, but, as we shall demonstrate later, their origin and method of formation are identical.

This resemblance of the nucleus to the vacuole is particularly evident in the cells of sporogenous tissue, where the vacuole is not usually present and where the nuclear cavity occupies the greater part of the cell. In many cases the nucleus was represented as constituting fully two-thirds of the cell contents (*fig. 13*), and the cytoplasm in such cases was a mere zone between the nuclear membrane and the cell wall. As we know so little in regard to the direct function of the nucleus in relation to metabolism, we are unable to account for the large size of the nuclear cavity in these sporogenous cells. But as these cells are characterized by the absence of a vacuole, this fact suggests that the nuclear cavity may here function as the vacuole functions in the vegetative cells. The writer regards this suggestion worthy of consideration, since the function of the nucleus is coming to be regarded more and more as an essential factor in constructive metabolism.

THE PRESENCE AND FORMATION OF PLASMATIC MEMBRANES IN THE CELL.

Of late years much attention has been given to the importance of plasmatic membranes and their relationship to osmosis. As a result of the investigations of Nägeli, Traube, and more particularly of Pfeffer, the cell is now regarded as an osmotic system composed of a series of membranes. In the typical plant cell there are three of these membranes commonly recognized, namely, the cell wall, the ectoplast, and the tonoplast.

Structurally the cell wall is entirely different from the ectoplast and tonoplast. Composed mainly of cellulose, it protects the inner protoplast, gives rigidity to the whole cell, and allows of a considerable internal osmotic pressure. As its method of formation has nothing in common with that of the inner plasmatic membranes, its presence will not form a part of the present discussion.

The two inner plasmatic membranes—which in the ordinary vegetative cell constitute the outer and inner limiting layers respectively of the primordial utricle—have the same general structure, and their methods of formation are identical, so far as we know. The ectoplast is present in every cell, no matter whether the cell is surrounded by a cell wall or not. It is very conspicuous in naked cells. In the ordinary cell, when not in a state of plasmolysis, the ectoplast is always found in close contact with the cell wall. As far as can be revealed by the microscope, it is merely a differentiated film of the cytoplasm.

The tonoplast is always to be found surrounding the watery fluid of the vacuole. As young cells and most sporogenous cells do not possess a vacuole, the tonoplast is not present. It is not as constant a cell structure, therefore, as the ectoplast. It is, like the ectoplast, merely a differentiated portion of the cytoplasm. Its formation may be followed readily by observing the gradual development of the vacuole which is associated with the growth of all vegetative cells. A complete series showing the gradual formation of the vacuole may be observed in any growing region, such as root tips or growing points. Accompanying the gradual accumulation of the watery contents of the vacuole, the gradual differentiation of the cytoplasm coming in contact with the cell sap becomes quite evident. Just what changes in the minute structure of the cytoplasm take place in formation of the membrane cannot be revealed by the microscope. In this connection, however, Pfeffer says as follows:

> Every mass of watery fluid present in the protoplasm must be surrounded by a vacuolar membrane to form a larger or smaller vacuole, while masses of plasma which have escaped from the cell also become clothed by a plasmatic membrane, and form large vacuolar bubbles in water, but not in plasmolysing solutions. From what has been said above, it follows that a plas-

matic membrane must be immediately formed on a freshly exposed surface as it comes into contact, not with plasma, but with other media and especially water. Nevertheless, the determining causes cannot at present be precisely defined, and it is hardly probable that the plasmatic membrane is simply the expression of the physical surface tension, which is necessarily always present. The latter may be of decisive importance, however, in the formation by means of the molecular forces exerted by it, while at the same time contact with the medium may cause the substances in the peripheral film to be precipitated in an insoluble form, which redissolves when returned to the interior of the plasma. Since a membrane is formed on every isolated fragment of plasma, even when its vital activity is reduced to its lowest ebb, it seems as if the actual exposure of a peripheral film induces the formation of the plasmatic membrane.

It is not my purpose to enter into a theoretical discussion as to the minute changes which take place during the formation of the plasmatic membranes, but merely to point out the fact that whenever the cytoplasm is exposed to a watery surface a membrane is formed and that all membranes thus formed are structurally identical, so far as can be revealed by the microscope. A third internal plasmatic membrane which has never been considered in this connection is the nuclear membrane. It too comes in contact with a watery fluid, the nuclear sap or karyolymph. As we shall see from the following observations, it is formed in identically the same manner as the tonoplast. It is nothing more than a modified film of cytoplasm, and on account of its similarity in structure and method of formation to that of the ectoplast and tonoplast the writer regards it as one of the series of plasmatic membranes of the cell.

THE FORMATION OF THE NUCLEAR MEMBRANE.

In the history of every nucleus of the higher plants which divides mitotically there are two stages in which this organ consists of nothing but chromatin. The first of these stages may be seen in any mother nucleus in its preparation for mitosis during the period of spindle formation. At this time the nuclear wall breaks down, the nucleoli and linin disappear, the karyolymph becomes diffused throughout the cytoplasm, and by the time the spindle is formed the only nuclear element that remains is the chromatin which has assumed the form of definite chromosomes. In his works on Cobaea and Gladiolus (1898, 1900) the writer called attention to the breaking down of the nuclear membrane. Beyond stating that the observations made on these forms have been confirmed by a study of the material used in the present investigation, it will be unnecessary to describe the process farther. It might be well, however, to call attention to the fact that it seems to be a general occurrence in the higher plants that the nuclear membrane breaks down either immediately preceding or during the process of spindle formation, and that therefore the mother nucleus is at this period devoid of a membrane.

The second stage in which the nucleus is devoid of a membrane may be observed in the young daughter nuclei previous to the accumulation of the karyolymph. It is this second stage which affords us an opportunity of following the course of events which leads to the formation of a membrane around each daughter nucleus. *Fig. 1* illustrates a stage in the pollen mother cell of *Passiflora coerulea* immediately after the chromosomes have reached the poles of the spindle. Here the chromosomes are shown still attached to the connective fibers of the spindle, but otherwise lie freely in the cytoplasm. Their individual identity may be easily observed. This stage is of very short duration, however, for the chromosomes soon fuse together, forming a single mass of chromatin. This fusion of the chromosomes is shown in *fig. 2*. This large irregularly shaped mass of chromatin comes in contact with the cytoplasm at every point of its outer surface. With the hope of detecting the very first indication of the formation of the nuclear membrane, many preparations showing this stage were carefully studied, but in no case could any trace of a membrane be found during this period. The nucleus at this time consists of nothing but a large single irregularly shaped mass of chromatin.

This stage, however, like the first, is of very short duration. The chromatin undergoes a change which is accompanied by the appearance of small but very distinct lacunae within the chromatin mass. *Fig. 3* shows two of these lacunae centrally situated. This is the first indication of the accumulation of karyolymph. These lacunae increase in size, flow together, and appear to force the surrounding chromatin outward. This gradual increase in the amount of karyolymph is well shown in *figs. 4* and *5*. *Fig. 4* shows a large central cavity in the chromatin mass, and the whole takes on a ring-like appearance in section. *Fig. 5* shows this still further developed, with two cavities filled with karyolymph. The chromatin here is doubtless preparing to take on the spirem condition of the ordinary resting nucleus. These stages (see *figs. 3, 4, 5, 6*) clearly show that this change in the shape of the chromatin is closely associated with the accumulation of the karyolymph. Up to the stage shown in *fig. 5* no change whatever could be detected in the cytoplasm that would indicate the formation of a membrane, although up to this time the chromatin has been in close touch, on all sides, with the cytoplasm. In *fig. 6*, however, is shown a stage in which the karyolymph has increased to such an extent and the chromatin has become so divided that the latter is no longer immediately surrounded by cytoplasm. Here for the first time the karyolymph comes in direct contact with the cytoplasm, and here also we have the first indication of a membrane. As shown in *fig. 6*, the membrane does not completely surround the chromatin, but is only observable at that region where the cytoplasm is directly exposed to the karyolymph. By the still greater increase in the amount of karyolymph which is accompanied by a still greater change in the shape of the chromatin (*figs. 7, 8*), this exposed region increases until the chromatin is completely surrounded by the karyolymph (*fig. 7*), and the latter becomes exposed to the cytoplasm on all sides. A complete series of stages was carefully examined, and it was found without exception that just as soon as a cytoplasm becomes exposed to the karyolymph there a membrane is formed, and where this exposed surface grows by the greater accumulation of the karyolymph the membrane increases accordingly. The result of this is a large central vacuolar structure (*figs. 8, 13*) containing chromatin in the spirem stage and commonly recognized as the resting condition of the mature nucleus.

While the formation of the nuclear membrane was most carefully followed in the pollen mother cells of Passiflora, and is here taken as the type, many other forms were also studied. Among these were the pollen mother cells of Cobaea, Gladiolus, Hedera, Lilium, Smilacina, and the archesporial cells of Equisetum. In all of these forms the process of nuclear membrane-formation was found to be practically the same as that described for Passiflora. In certain cases, however, it was found that in the accumulation of the karyolymph and the dividing of the chromatin mass the process differs slightly. This was particularly evident in the archesporial cells of *Equisetum limosum*. Here, as in Passiflora, the chromosomes unite to form a single mass of chromatin at each pole of the spindle (*fig. 9*). In the next stage, however, instead of only two or three lacunae appearing in the chromatin, a large number make their appearance (*fig. 10*). These increase in number, grow independently, and do not flow together in this early stage as they do in Passiflora. The result is—as shown in *figs. 10, 11, 12*—that in section view we do not have that ring-like appearance of the chromatin which was found to be so characteristic of Passiflora.

Fig. 11 shows a condition in which the lacunae have increased to such an extent as to extend beyond the chromatin, and the contained karyolymph is therefore directly exposed to the cytoplasm in these places. The result here, as shown in *fig. 11*, is an incomplete membrane surrounding each daughter nucleus, with the membrane only visible in those regions where the cytoplasm is exposed to the karyolymph.

From the above observations it would seem that as the chromatin of the daughter nucleus divides up in its preparation to pass into the spirem condition there is secreted a watery fluid commonly recognized as the karyolymph or nuclear sap. The karyolymph is first contained within the chromatin mass, but its volume increases and extends beyond the chromatin and consequently comes in contact with the cytoplasm. There seems little question that it is the exposure to the cytoplasm which causes the formation of a membrane around the nucleus, and the nuclear membrane is therefore a cytoplasmic structure.

GENERAL CONCLUSIONS.

It is quite natural to suppose that the secret of the origin of the cell nucleus can only be revealed by a study of the most primitive types of life. That such a supposition has influenced many investigators becomes quite evident when one glances over the enormous amount of literature that has accumulated on the cytology of the Bacteria and the Cyanophyceae. On these primitive forms a great deal of work has been done with the hope of throwing light on the origin of the nucleus. Through the efforts of Bütchli (1890, 1892, 1896), Fischer (1891, 1897), Zacharias (1887, 1890, 1897), Pella (1894), Macallum (1895, 1900), and many others, much valuable data has been accumulated, but as yet no satisfactory conclusions have been reached. This failure is probably due to the fact that many investigators have not a correct morphological conception of the nucleus as we find it in the higher types of life.

As a result of the above studies on the formation of the nuclear membrane, the writer's conception of a nucleus has been considerably modified. Instead of the nucleus being regarded as a sac containing karyolymph, chromatin, nucleoli, linin, and a membrane, the chromatin alone is regarded as the only permanent morphological constituent of the nucleus. The karyolymph and the membrane are merely temporary physiological results. The accumulation of the nuclear sap is the result of protoplasmic activity. It is first secreted within the chromatin mass and later surrounds it. The cytoplasm coming in contact with the nuclear sap forms a membrane in precisely the same manner as it forms the tonoplast when it comes in contact with the cell sap of the vacuole. The writer therefore regards the nuclear sap as no more permanent than the cell sap, and the nuclear membrane as no more permanent than the tonoplast. Furthermore, as we have shown that the nuclear membrane is of cytoplasmic origin, this structure is to be regarded more as the inner limiting layer of cytoplasm than as a constituent of the nucleus.

To convince one's self that the chromatin is the only permanent element of the nucleus, it is only necessary to observe the various stages of mitosis. Immediately after the nucleus divides there are two masses of chromatin in the cell. For some time these masses of chromatin are surrounded by neither karyolymph or membrane, and yet no one will deny that they are nuclei. The law that the nucleus never arises *de novo*, but always from the division of a preexisting nucleus, does not hold good if we regard the membrane, karyolymph, or nucleoli as morphological elements. We must either change this law of the permanency of the nucleus or change our morphological conception of this organ. As there seems to be no doubt as to the permanency of the chromatin from cell to cell, and as the other constituents of the mature nucleus are physiological results which are entirely renewed with each succeeding mitosis, there is good reason to regard the chromatin alone as the nucleus, whether it is surrounded by karyolymph and membrane or lying freely in the cytoplasm.

The question as to the existence of a nucleus in the Cyanophyceae and Bacteria has been the subject of controversy for a great many years and even up to the present time it has not been satisfactorily shown that such an organ exists in the cells of these primitive organisms. Among the modern workers in this field, as Zukal (1892), Palla (1894), Nadson (1895), Bütchli (1892-1896), Zacharias (1897), Fischer (1897), and Macallum (1895–1900), a great divergence of opinion is expressed. Some claim that a nucleus is present; while on the other hand many claim that no structure exists that can be interpreted as a nucleus: others again have shown quite conclusively that chromatin-like granules are present, but hold that these do not represent the nucleus. Of the writers who hold this latter view Macallum (1900) expresses himself probably more strongly than the others. In his work "On the cytology of non-nucleated organisms" he finds that the cells of Beggiatoa and of the Cyanophyceae contain granules which stain like chromatin and give all its known reactions. Although he regards these structures analogous to chromatin, he concludes that "there is no nucleus nor any structure which resembles a nucleus in the Cyanophyceae." He holds a similar view in regard to the Beggiatoa cell

As the highly complex nature of the typical nucleus has doubtless been the result of the demand for a physiological division of labor in the cell, there is no reason why we should expect to find such a condition in the primitive cell of the Cyanophyceae or Bacteria. The majority of the writers who have investigated the cytology of these forms agree that chromatin-like granules exist in these primitive cells, but that these granules are surrounded by neither nuclear sap nor membrane, and many therefore do not regard these granules as representing the nucleus. As I have attempted to show that the so-called nuclear membrane is merely the inner limiting membrane of cytoplasm, and that every typical cell passes through a phase in its history when it consists of nothing but chromatin granules, the writer sees in this a possible reconciliation for the divergence of opinion that is held in regard to the nucleus of the Cyanophyceae. For might we not regard that stage of the daughter nucleus when it is devoid of a membrane as representing a phase in its ontogeny which approaches that primitive condition which we find in the cells of the bacteria and Cyanophyceae, although the chromatin-like bodies in the cells of these forms may not be the ancestral nucleus.

In conclusion, I take pleasure in acknowledging my indebtedness to Dr. Bradley M. Davis and Dr. Charles J. Chamberlin for advice, and to the Botanical Department of the University of Chicago for the excellent facilities for cytological research which were placed at my disposal.

SUMMARY.

The results of the above observations may be briefly summarized as follows:

The typical nucleus of the higher plants is a water cavity structurally similar to that of the cell vacuole.

The chromatin is the only permanent constituent of the nucleus. The karyolymph, linin, nucleoli, and membrane are renewed with each succeeding mitosis.

The nuclear membrane originates like the tonoplast. It is formed by the cytoplasm coming in contact with the karyolymph just as the tonoplast is formed by the cytoplasm coming in contact with the cell sap.

The karyolymph is no more permanent than the cell sap, and the nuclear membrane is no more permanent than the tonoplast.

As the nuclear membrane is of cytoplasmic origin, it is regarded as the inner limiting membrane of cytoplasm rather than as a constituent of the nucleus.

Although the chromatin granules found in the cells of the Cyanophyceae and Bacteria are surrounded by neither karyolymph nor membrane, these granules nevertheless represent the nucleus, since every highly organized nucleus passes through a stage in its development when it consists of nothing but chromatin.

It is further suggested that the primitive nucleus probably did not secrete a karyolymph and therefore no nuclear membrane was formed.

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EXPLANATION OF PLATE XV.

The figures were drawn with the aid of Abbe's camera lucida, Zeiss homogeneous immersion, objective $\frac{1}{12}$, apert. 1.25, compensating ocular no. 8.

FIG. 1. A portion of a pollen mother-cell of *Passiflora coerulea* during nuclear division; the figure shows the chromosomes of one daughter nucleus at the poles; the connective fibers are still attached to the chromosomes but otherwise the latter lie freely in the cytoplasm.

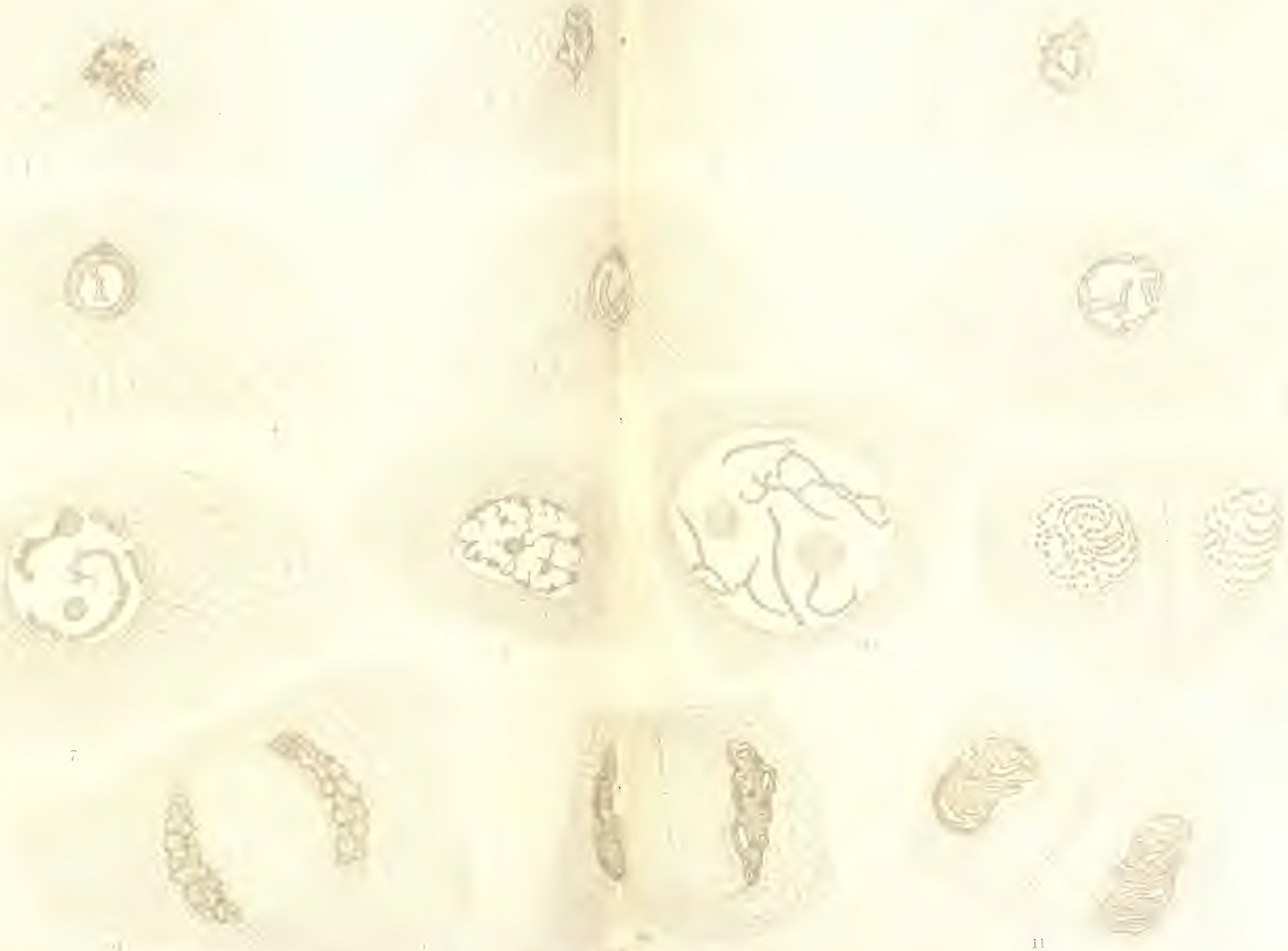
FIG. 2. A later stage of the same; the chromosomes have fused together and the daughter nucleus is represented as a large single irregularly shaped mass of chromatin.

FIG. 3. Shows the presence of small lacunae within the chromatin mass of the daughter nucleus; these lacunae are the first indications of the accumulation of the nuclear sap or karyolymph.

FIG. 4. Shows an increase in the amount of karyolymph; the smaller lacunae have united, forming one central cavity and the chromatin has the appearance of a sphere with the karyolymph in the center; in section the daughter nucleus has the appearance of a ring of chromatin surrounding a central cavity of karyolymph.

FIG. 5. Shows a somewhat later stage than *fig. 4;* the karyolymph has increased in quantity and the chromatin has undergone still further modifications in its shape; up to this stage no trace of a nuclear membrane could be detected; the chromatin lies freely in the cytoplasm.

FIG. 6. This shows a stage in the daughter nucleus where the karyolymph has increased to such an extent and the chromatin has become so divided that the latter is no longer completely surrounded by cytoplasm; as a result the cytoplasm is for the first time exposed to the karyolymph; at the region



LAWSON on NUCLEAR MEMBRANE

of contact of the karyolymph with the cytoplasm we can observe the first indication of the nuclear membrane.

FIG. 7. Shows a still later stage where the karyolymph has increased considerably and the chromatin has become divided to such an extent as to expose the cytoplasm to the karyolymph on all sides, and as a result we have a complete membrane formed; the daughter nucleus is now perfectly spherical, containing all the elements of a mature nucleus.

FIG. 8. Shows a daughter nucleus with the chromatin in the spirem stage; this is after the cell plate has been formed and the accumulation of the granular zone around the daughter nucleus indicates that it will soon prepare for the second division.

FIG. 9. An archesporial cell of *Equisetum limosum;* the chromosomes have fused together and each daughter nucleus consists of a large irregularly shaped mass of chromatin.

FIG. 10. The same at a later stage, showing several lacunae containing karyolymph within the chromatin mass of each daughter nucleus.

FIG. 11. A still later stage showing an increase in size and number of the lacunae; some of the latter have increased to such a size as to extend beyond the chromatin, and as a result the cytoplasm becomes exposed to the karyolymph; the result is the appearance of a membrane at the region of contact of the cytoplasm with the karyolymph.

FIG. 12. Shows a stage where the volume of karyolymph has increased to such an extent as to completely surround the chromatin; the cytoplasm comes in contact with the karyolymph on sides resulting in the formation of a complete membrane about each daughter nucleus.

FIG. 13. Showing the vacuolar appearance of the mature nucleus of the archesporial cell of Equisetum; it also shows the relative size of these nuclei to the cytoplasm.

OOGENESIS IN SAPROLEGNIA.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XLVI.

BRADLEY MOORE DAVIS.

(*Concluded from p. 249*)

THEORETICAL CONSIDERATIONS.

THE writer has once before (Davis, 1900) treated a number of topics suggested by recent studies on the Phycomycetes. The advances in this field of research, and also among the Ascomycetes, have been significant, and we seem to be nearing a point where much clearer conceptions of morphology and phylogeny may result. In this paper we shall take up a number of considerations suggested by this and other investigations since 1900, and for convenience they will be grouped under headings as follows:

1. Homologies of the coenogamete.
2. Origin and evolution of the coenogamete.
3. Pyronema and coenogametes among the Ascomycetes.
4. Phylogeny of Phycomycetes and Ascomycetes.
5. The nucleus of Phycomycetes in ontogeny.

HOMOLOGIES OF THE COENOGAMETE.

The writer suggested the term "coenogamete" (Davis, 1900) as appropriate to fusing multinucleate masses of protoplasm whose individual nuclei are actually or potentially sexual. Stevens's first paper (1899) on *Albugo Bliti* really opened the field in its newer cytological aspects. Since then Harper (1900) has described for the ascomycete Pyronema strikingly similar conditions, as has also Juel (1902) for Dipodascus; and from the studies of Gruber (1901) we know more about the sexual processes in the Mucorales. Harper's results will be considered in a special connection. It is important at the outset that we understand clearly the homologies of the coenogamete.

Are all coenogametes homologous with one another, and from what have they been derived among the algae? It will be agreed that the Mucorales, *Albugo Bliti*, and Pyronema illustrate completely the conception of a coenogamete. It is a part of our problem to determine the relation of these conditions to the sexual organs in other species of Albugo, and in Peronospora, Pythium, and the Saprolegniales. There may be some hesitancy in following the series of homologies that the writer will propose, and the evolutionary history to be suggested; but he can see only two possibilities, of which one is so obscure that it seems almost impossible in the light of our present knowledge, incomplete as it is.

The most important structures in the coenogamete are the nuclei, and there can be hardly any question that they individually stand for energids, which among the algae are independent uninucleate gametes. Stevens's (1899) term "compound oosphere" expressed very well this conception of the conditions in *Albugo Bliti*. It was employed when this form was the only type known presenting the structure implied by the phrase, and these conditions might have been purely exceptional. But we now know from later studies of Stevens (1901) that other species of Albugo, *A. Portulacae*, *A. Tragopogonis*, and *A. candida*, have phases of ontogeny identical with the essential periods of oogenesis in *A. Bliti*, and may be brought into very intimate relation to the latter species. We also know that the coenogamete is not restricted to the Peronosporales, but is characteristic of the Mucorales, and is found also among the Ascomycetes. It is not likely that we shall retain the phrase "compound oosphere," for a broader conception will probably take its place, but a purpose has been served and a field opened to investigation that was quite undreamed of by the earlier investigators of the Phycomycetes.

The nuclei of coenogametes are homologous with nuclei in a gametangium destined to develop independent sexual cells. Hartog's (1891) conception of the nuclei in the periplasm of Peronospora as representing degenerate gametes has been completely justified, and there are very good reasons for believing that the nuclear divisions in the oogonium and antheridium of the Saprolegniales and Peronosporales are "phylogenetic reminiscences of the formation of gametes." The attempts to establish special functions for these mitoses as reduction divisions for the eggs have been unsuccessful.

The oogonia and the antheridia of the Peronosporales, Saprolegniales, and Pyronema are the homologues of gametangia, and consequently of that simplest type of coenogamete, as illustrated in the Mucorales. There is everything in the morphology of these structures to favor these conclusions, but only recently have we known the details of protoplasmic organization. When an entire gametangium functions as a gamete, as in the Mucorales, it becomes a coenogamete. In Pyronema, Albugo, and the multinucleate eggs of the Saprolegniales the coenogametes are restricted portions of the protoplasm in such gametangia, but it is obvious that in Pyronema and Albugo, the gametangium behaves as a whole in a manner strictly similar to the fusion of the coenogametes in the Mucorales. It should be noted that these homologies are quite independent of the problem of the origin of the coenogametes in the various groups. That topic will be treated in the next section of the paper.

Stevens (1901) has carried the homologies a step farther in suggesting that the receptive papilla from the oogonium of the Peronosporales marks the position of the pore that develops in the gametangia of algae to give entrance or exit to the sexual elements. This is a very interesting comparison and is worth following to its limits. Thus the points of fusion of the coenogametes of a mold may be homologous with the points of exit of the motile gametes from the gametangium of some algal ancestor.

The term "coenogamete" should be employed in the strict sense indicated when the term was proposed (Davis, 1900, p. 307). It is a structure containing more than one gamete nucleus, and generally very many functional or potential gamete nuclei. It is generally homologous with a gametangium, the binucleate and trinucleate eggs of the Saprolegniales and the multinucleate eggs of *Sphaeroplea annulina Braunii* (Klebahn, 1899) presenting the only exceptions, for the oogonia of *Albugo*

Bliti, *A. Portulacae*, and *A. Tragopogonis* really act as a whole, and it is hardly possible to separate in these forms the coenogametes (oospheres) from the gametangia. When we say that the oogonium of Albugo, Peronospora, Sclerospora, and Pythium acts as a whole, we mean that the periplasm is not to be considered as waste material, but as a specialized region of the cell, with important functions in relation to the eggs, which it helps to protect by assisting in the formation of heavy walls. The Mucorales, Pyronema, and these three species of Albugo furnish the best known illustrations of coenogametes.

ORIGIN AND EVOLUTION OF THE COENOGAMETE.

There seem to be only two possible sources of the coenogamete. It is conceivable that a uninucleate sexual element might become multinucleate, perhaps through such an increase in the protoplasmic content that more than one nucleus would be required to control satisfactorily its activities. The second possibility is an origin from a multinucleate gametangium that has given up the production of uninucleate gametes, and acting as a unit becomes itself a sexual organ, a coenogamete. Such an evolutionary process would find its analogy in those sporangia (conidia) of certain species of Pythium and Peronospora, which now germinate as a whole (by a tube) instead of forming zoospores.

The first possibility has absolutely no evidence in its support. There is no series of forms whose sexual cells pass from a uninucleate condition to a multinucleate. There are no indications that such an evolutionary process has ever taken place among plants. There are only two instances known where eggs, free from periplasm, are multinucleate. The eggs of Albugo are so intimately associated with periplasm that they cannot be considered apart from the gametangium in which they lie. These two examples are the binucleate and trinucleate eggs of the Saprolegniales and the multinucleate eggs of *Sphaeroplea annulina Braunii*. Our investigations of Saprolegnia have shown that the processes of oogenesis in that group have as an end the sacrifice rather than the preservation of nuclei, and the uninucleate condition is evidently the goal of evolution. Klebahn's (1899) and

Golenkin's (1899) studies of Sphaeroplea are incomplete in certain cytological details of oogenesis, and the fact that the eggs of some forms are uninucleate suggests caution before laying emphasis on the multinucleate condition. It is possible that further study will relate the multinucleate eggs to the uninucleate, as in Saprolegnia.

What evidence have we of the second possibility, *i. e.*, the origin of the coenogamete from a multinucleate gametangium which, ceasing to form uninucleate sexual cells becomes itself a coenocytic gamete? Most important is the exceedingly interesting series of four species of Albugo described with so much detail by Stevens (1901). We cannot take up this investigation except to notice that the four species form a well-graded series in which the evolutionary direction is clear and very important for the conclusions that we are striving to establish. The oospheres of *Albugo Bliti* and *A. Portulacae* contain many functional gamete nuclei, that of *A. Tragopogonis* several potential and several functional, and that of *A. candida* several potential and one functional. In this series the coenocentrum is very small in *A. Bliti* and *A. Portulacae*, larger in *A. Tragopogonis*, and very large and strongly chemotactic in *A. candida*. A fifth form has been added to this series by Ruhland (1902), who finds that *Albugo Lepigoni* is even more highly specialized than *Albugo candida*, since it contains an extraordinarily large coenocentrum. The evolution in complexity is plainly from *A. Bliti* to *A. candida* and *A. Lepigoni*, that is, from the multinucleate egg to the uninucleate. And this series offers the most striking evidence against the evolutionary possibility considered in the previous paragraph.

Now, the multinucleate eggs of Albugo are not the most primitive types of coenogametes, because they contain only a portion of the total number of the nuclei in the gametangium, many of the sister nuclei passing into the periplasm. They are not as simple as the coenogametes of the Mucorales, nor yet as primitive as the oogonium of Pyronema, which has no periplasm, although it sacrifices a large number of nuclei in the conjugating tube (trichogyne), and by this specialization presents conditions more complex than the molds.

It is the specialization of a periplasm simultaneous with the reduction in the number of functional gamete nuclei that has made possible the elaborately organized oogonium of Peronospora, Sclerospora, Albugo, Araiospora, and to a lesser degree Pythium. And the coenocentrum is perhaps most largely responsible for the highest specialization. The coenocentrum largely influences and perhaps controls the position and structure of the eggs. The larger the coenocentrum, the more direct is the effect on neighboring nuclei, and the greater is the benefit to such nuclei as are so fortunate as to be within its sphere of operations. So in the struggle for existence among potential gamete nuclei in the oogonium, the coenocentrum has a power of assistance that, according to its degree of development, determines the structure of the egg, whether multinucleate or uninucleate. The evolutionary trend is physiologically precisely the same as is shown among the algae (Fucales, Vaucheria), when potential gamete nuclei are sacrificed to provide functional nuclei with a large amount of richly nourished protoplasm.

But it should be noted that, although the evolutionary processes in the Peronosporales have resulted in uninucleate eggs, these structures are not strictly homologous with the eggs of algae. They are homologous only in the sense that the eggs of Volvox, Fucus, Vaucheria, Chara, and several other highly developed algae are homologous. In these algae the eggs have an ancestry from much simpler types of gametes, and relationships must be traced through these or perhaps through older forms of asexual spores. The oogonium of the higher Peronosporales has come through a series of coenogametes of which *Albugo Bliti* represents a certain stage, but whose earlier forms must have been simpler. The primitive conditions probably had a structure comparable to the coenogametes of the Mucorales, and that type of structure finds its nearest approach among the algae in the gametangia that discharge numerous gametes, as illustrated by Cladophora and many of the Siphonales.

But it will immediately be asked: What are we to do with such algal types as Vaucheria, Sphaeroplea, Oedogonium, etc.? Have they no relation to the fungi? This will be considered under the topic "Phylogeny of the Phycomycetes and Ascomycetes." It is important that we emphasize now the evolutionary process brought out by Stevens's work on the four species of Albugo, and extend the results of that study to the Penorosporales as a whole. Accordingly we have good reason to believe that the uninucleate eggs of *Albugo candida*, Peronospora, and Pythium have not been derived from the eggs of algal ancestry, but from coenogametes which passed through the stage illustrated by *Albugo Bliti*, and came from much simpler conditions, probably resembling in many respects the coenogametes of the molds and Pyronema.

An origin of the simplest types of coenogametes (molds and Pyronema) from gametangia of algae presents certain difficulties that should be discussed. The process would involve a change in the activities of a structure from one where the nuclei show a considerable degree of independence to one in which the nuclei cooperate in a coenocytic cell that acts as a unit. An evolutionary process comparable to the above must have taken place with the development of the multinucleate zoospore of Vaucheria, if its nuclei stand for the numerous zoospores generally formed in the terminal sporangia of the Siphonales. And a similar evolution, as has been mentioned before, is shown in the development among the Peronosporales of conidia (which germinate by tubes) from sporangia (conidia) that form zoospores. Such conidia and the zoospores of Vaucheria are not considered the equivalent of tissues, but units in their physiological behavior, just like uninucleate spores.

Similarly, the coenogamete is not the equivalent of a tissue, and must not be considered as made up of independent gametes associated together because their cytoplasm is fused into a common mass. It exhibits the same sort of individuality as any coenocytic cell or structure. We no longer draw sharp lines between uninucleate and multinucleate cells, for we realize that the transformation of the first into the second is a very simple matter, and that the unity of the coenocyte is not disturbed by its having several or many nuclei, for these do not occupy fixed positions in the cell but wander with the varying movements of the protoplasm. The coenogamete is as much an individual cell as the uninucleate gamete, and distinctions can no more be drawn between these two structures than between the adjacent uninucleate and multinucleate cells of many plants (Chara, Rhodophyceae, etc.). In view of its structure and behavior the term "coenogamete" seems to the writer appropriate.

PYRONEMA AND COENOGAMETES AMONG THE ASCOMYCETES.

Harper's (1900) investigation of Pyronema has established a condition in the Ascomycetes very similar to that among the Phycomycetes. Pyronema has as conspicuous a coenogamete as the Mucorales or *Albugo Bliti*. Its peculiarities do not affect the essential cytological structure of the fusing multinucleate masses of protoplasm whose gamete nuclei unite in pairs, as in *Albugo Bliti* and probably in the molds. The sexual apparatus of Pyronema differs from the molds chiefly in the development of that specialized structure the conjugating tube (trichogyne). This organ is manifestly of advantage because it effects a union with the antheridium, and probably, as Harper suggests, represents the same sort of outgrowth from a sexual element as a trychogyne. The nuclei in the conjugating tube break down, and the structure finally becomes merely the channel through which the protoplasm from the antheridium flows into the oogonium. This movement of the protoplasm is very similar to *Albugo Bliti*, and the resemblance is carried still farther in the distribution and fusion of the gamete nuclei in pairs throughout the oogonium. The "receptive papilla" of Albugo is developed from the oogonium, and the conjugating tube in Pyronema may be considered an elaboration of such a growth tendency. Periplasm is lacking in Pyronema, but the mass of nucleate protoplasm that passes into the conjugating tube may relieve the oogonium of those conditions that result in the extensive degeneration of potential gamete nuclei in Saprolegnia or the somewhat similar conditions affected by the differentiation of a periplasm in the Peronosporales.

It is not to be supposed that the coenogametes of Pyronema are closely related to those of the Mucorales or the Peronosporales, excepting as all of these structures are the homologues of gametangia. But it is important that we should recognize this condition among the Ascomycetes as one that further study may show to be not uncommon in the group. Juel (1902) reports it for Dipodascus. Miss Nichols's (1896) studies on Ceratostoma, while inconclusive in cytological details, are of importance in this connection. She has described and figured multinucleate oogonia (archicarps) and antheridia, which are said to fuse. They are apparently coenogametes, and it is probable that these structures will be found in other genera of the Pyrenomycetes and Discomycetes. There are several forms whose archicarps suggest a coenocytic structure (Eremascus, Ascobolus, Sordaria, Eurotium, etc.).

The student of the homologies and evolution of the sexual organs among the Ascomycetes now finds himself face to face with the same problem that has been presented to Stevens and myself for the Phycomycetes. What is the relation of the uninucleate gamete (*e. g.*, Sphaerotheca) to the multinucleate? Which condition is the more primitive?

There is likely to be some confusion of homologies among the sexual organs of the Ascomycetes. The oogonium (archicarp) of Sphaerotheca is morphologically a gametangium, and so is the antheridium, but both structures are physiologically gametes. The oogonium and antheridium of Pyronema are morphologically gametangia, so that in comparing these two forms we are dealing with homologous structures. Of course, we use them merely as illustrating certain sexual conditions; indeed, they are almost the only Ascomycetes whose sexual organs have been thoroughly studied, with the exception of certain lichens and the Laboulbeniaceae in which the conditions are very different and will be considered later.

The problem then will be: Did the uninucleate condition of the gametangium, as represented by Sphaerotheca, come from a multinucleate gametangium (coenogamete) illustrated by Pyronema, or is it the progenitor of the latter? We have no series of forms in the Ascomycetes such as the four species of Albugo studied by Stevens to help us to a conclusion. But the problem in the Ascomycetes seems to be identical with that of the

Phycomycetes discussed in the previous sections of this paper. To derive a multinucleate gamete (Pyronema) from a uninucleate (Sphaerotheca) involves an evolutionary process quite unknown to botany. To derive a uninucleate gamete from a coenogamete merely demands a gradual reduction of the number of gamete nuclei, a process which we know to have taken place in several groups of algae independently of one another, and one which is beautifully shown in Stevens's series of four species of Albugo.

Harper (1900, pp. 388, 389) seems to be undecided as to the developmental relation of conditions in Sphaerotheca to such as are presented in Pyronema. He shows that the oogonium of Sphaerotheca could easily be given the form of Pyronema by the development of the beak into a conjugating tube with some minor changes in the position of the antheridium. But he disregards the internal changes necessary to derive a coenogamete from a uninucleate gamete. And at the end of the same paragraph he says: "Still I am inclined to believe that the reverse process has taken place and that the sexual apparatus with the trichogyne represents the more primitive type for the Ascomycetes." To the writer resemblances of form have very little value in such comparisons, and relationships must be traced through agreement in the details of protoplasmic activities. And again, as Harper points out, the general morphology of the Erysipheae is much higher than that of Pyronema. But Professor Harper by his last statement has warded off criticism, and perhaps, with the evidence from Albugo and Saprolegnia before him, he will feel more certain, with the writer, that the coenogamete when related to the uninucleate gamete always represents more primitive conditions.

And this conception has a very interesting relation to the possibility of deriving the trichogynes of lichens and the Laboulbeniaceae from a primitive type of sexual organ that may have been a coenogamete. Of course, there is no reason why a uninucleate gamete (archicarp) among the fungi might not develop a simple trichogyne, as has been done in the Rhodophyceae, but the trichogynes of the lichens and the Laboulbeniaceae are generally systems of cells quite distinct from the female gamete (carpogenic cell). These conditions are nowhere presented in the red algae, and it is very difficult to understand how a uninucleate gamete could develop such elaborate structures. But taking the suggestion of Harper (1900) that the conjugating tube of Pyronema is an outgrowth similar to a trichogyne, there are presented possibilities of various elaborate structural developments, because the outgrowth has so much protoplasm and many nuclei to draw upon. The evolutionary tendency of a coenogamete is to reduce the number of functional gamete nuclei, generally by the sacrifice of many, but these with accompanying cytoplasm are sometimes employed to advantage in developing structural adaptations. In the Peronosporales the advantage lies in the activities displayed by the periplasm in assisting to form the spore wall. Araiospora (Thaxter, 1896) utilizes the periplasm to develop a cellular envelope surrounding the egg. The conjugating tube of Pyronema is evidently a desirable specialization, insuring a union with the male organ. Perhaps the elaborate multicellular trichogyne is the result of similar activities on the part of archicarps that are or were coenogametes.

It is obvious that this possibility has very important relations to comparisons that have been made between the trichogynes of the Ascomycetes and those of the Rhodophyceae. It is not easy to homologize these structures, and it is difficult to conceive the evolution of any group of the Ascomycetes from the red algae. The Laboulbeniaceae exhibit certain strong resemblances in a general similarity of cell structure, but peculiarities confront one whenever the comparison is carried into details. Nevertheless a relation of this group to the Rhodophyceae remains a possibility, although it can hardly be more than mere speculation until we have much greater cytological knowledge of sexual processes here and in other Ascomycetes.

But the coenogamete may be found widespread among the Ascomycetes, which suggests a new point of view that is worth attention. It is possible that the coenogamete may come to be recognized as a primitive type of sexual organ in the Ascomycetes, as the writer believes it to be for certain groups of the

Phycomycetes (Mucorales, Saprolegniales, and Peronosporales). Perhaps the complex conditions of such highly specialized groups as the Erysipheae, lichens, and Laboulbeniaceae may be related to the peculiar activities and possibilities of diverse development in this interesting sexual cell, the coenogamete. Sphaerotheca may readily stand as the last step in a process of nuclear reduction. Pyronema certainly exhibits the tendency to utilize superfluous nuclei and protoplasm in developing that advantageous structure, the conjugating tube. And possibly such tendencies might result in the production of the elaborate trichogynes of the lichens and Laboulbeniaceae, and in the latter group the structure that resembles the procarp of the red algae.

PHYLOGENY OF THE PHYCOMYCETES AND ASCOMYCETES.

The reader has probably already noted that some standpoints have been taken at variance with the generally accepted ideas of relationship among the Phycomycetes and Ascomycetes, and of these groups to an algal ancestry. A protest is sure to be offered against the disregard of certain Phycomycetes and algae in the attempt to derive the Mucorales, Saprolegniales, and Peronosporales from an ancestry with coenogametes.

There are some Phycomycetes that are much closer to the algae than any of the groups mentioned above. Monoblepharis and Myrioblepharis (Thaxter, 1895) exhibit sexual organs, zoospores, and vegetative structure with striking resemblances in various particulars to such algae as Vaucheria, Oedogonium, and Sphaeroplea. The homologies can hardly be questioned and will not be elaborated here. These fungi, and possibly some of the Leptomitaceae, seem to be close to heterogamous (oosporic) algae and may well have come from that region of the Thallophytes. The family Leptomitaceae includes some very remarkably types which have been well described by Thaxter (1896). Their position must remain somewhat uncertain until we know the nuclear structure of the sexual organs, but the general morphology of some forms indicates a relationship to the Peronosporales. Araiospora (Thaxter, 1896) is likely to prove especially interesting as illustrating an activity of the periplasm in forming a cellular envelope around the oospore, that is not shown in any other type and has important bearings on the possible development of tissues of considerable complexity by the coenogamete.

But many difficulties present themselves when the Monoblepharidae are made a starting-point for a line of ascent to the Peronosporales, as is done by Trow (1901, pp. 306, 307) when he arranges in series Monoblepharis, Saprolegnia, Pythium, and Albugo (Cystopus). These forms are not so similar that close relationships are manifest either through morphology or ontogeny. Under the most favorable interpretation it must be granted that they are at present widely divergent and highly specialized types, even assuming that ancestral forms now extinct might have had more general characters. Such speculations are, of course, entirely justifiable, if they do no violence to developmental history.

However, as has been shown, such an evolution must assume either that uninucleate gametes became multinucleate or that differentiated eggs (Monoblepharis) lost their high state of specialization and finally their entire individuality in the coenogamete of the Peronosporales. Both processes are opposed to what we know has been the evolutionary history of sexual cells in several divergent and independent groups of algae. We are called upon to accept a "subjective phylogeny" opposed to well-established cytological processes.

The situation is somewhat similar to that presented to the Brefeldian school with respect to the origin of the ascus from the sporangium of a mold. Harper has shown that the protoplasmic activities of sporogenesis in the sporangium and ascus are along entirely different lines with nothing in common. To the writer such differences in cytological processes completely outweigh conclusions from any series of types presented on a basis of general form resemblance. Form resemblance between the ascus and sporangium can have very little morphological value until it be accompanied by evidence satisfactorily explaining the differences of protoplasmic organization and behavior. And the elaborate phylogenetic structure built by Brefeld and his followers is sadly in need of a foundation, if not already a ruin. Form resemblance must be in complete harmony with cytological conditions to have weight.

Trow (1901) has criticised a developmental line that the writer indicated in 1900, which, he states, is an attempt to derive Oomycetes from a zygomycetous ancestry, and which he considers an example of "subjective phylogeny." I have carefully examined what was written in that paper (Davis, 1900, pp. 304–9), and, not finding any reference to specific phylogenetic ancestry, am compelled to suggest to Trow a more careful reading and citation of that article. I presented there suggestions for the developmental history of the sexual conditions in the Peronosporales from coenogametes derived from the gametangia of algae. These coenogametes at a certain stage in the process of sexual differentiation would be similar to the sexual organs of the Mucorales. The molds were used to illustrate a well-defined sexual condition, which is not at all suggesting that they are the ancestors of the Peronosporales (Oomycetes).

But the present investigation of Saprolegnia, together with Stevens's (1901) later studies on Albugo, have strengthened my faith in the suggestions of that former paper (Davis, 1900). The Mucorales, Saprolegniales, and Peronosporales are generally acknowledged to be closely related groups, but it seems probable that the affinities are only through the somewhat similar conditions of sexual organs derived from the coenogametes of some common ancestry. There are many peculiarities of life-habits, life-histories, and methods of asexual reproduction. Of these three groups the Mucorales present the simplest conditions of sexuality and illustrate most nearly the structure of the primitive coenogamete. The Peronosporales and Saprolegniales are difficult to relate to one another, for the higher development of the coenogamete is apparently progressing along divergent lines. In the Peronosporales the protoplasmic differentiation in the oogonium determines a centrally placed egg in an enveloping periplasm, for a single coenocentrum dominates the process of oogenesis. In the Saprolegniales the ooplasm gathers by cleavage around a number of coenocentra, and all the protoplasm passes into the resulting eggs. To the writer the second process seems less highly specialized than the first and the Saprolegniales lower than the Peronosporales with respect to sexual processes. But oogenesis in these two groups shows such marked differences in their evolutionary tendencies that the question of the relative level of each process has very little import.

The Saprolegniales are more difficult to understand in relation to a coenogamete ancestry than the Peronosporales, because the many eggs without periplasm suggest at once the stage in heterogamy illustrated by Sphaeroplea. However, the processes of oogenesis are probably very different in the two types. The egg origins of Saprolegnia have a great many potential gamete nuclei, and that stage indicates strongly the coenogamete ancestry. By numerical reduction of the gamete nuclei the egg of Saprolegnia has proceeded to a point where it has almost ceased to be a coenogamete, that condition only being presented in the bi- and trinucleate eggs.

It will be difficult for many to give up the idea that Vaucheria is not a suitable starting point for the line of higher Phycomycetes. The chief objection is the incompatibility of the processes of oogenesis where relationship demands agreement even in the details of cytology. We have only the accounts of Oltmanns (1895), Behrens (1890), and Klebahn (1892, p. 237), which are not in complete agreement on some important points, and perhaps further study may reveal conditions that are only suspected. In considerations of this sort it is important to know the relation that Vaucheria bears to the algae as a whole. Although generally classed among the Siphonales, Vaucheria has little in common with that group excepting the coenocytic thallus. It stands alone as the only heterogamous form (oosporic) in a very large assemblage characteristically isogamous. Generally presented as a type of the Siphonales, Vaucheria is not really representative of that group, which is much better illustrated by such forms as Codium, Bryopsis, or Penicillus. The affinities of Cladophora with the Siphonales are now better understood, and we see that this form except for the septate thallus — whose cells are, however, multinucleate — has all the characters of the Siphonales. It is this region of the algae (Cladophora, Codium, etc.) that presents to the writer's mind conditions most nearly like the ancestry of the Mucorales, Saprolegniales, and Peronosporales, that is, an ancestry whose sexual organs were coenogametes. Perhaps, however, further studies on the oogonium of Vaucheria may bring this structure into harmony with coenogametes.

The coenogamete among the fungi must have come through the homologous structure among the algae, the gametangium. We cannot suppose that such gametangia were highly specialized. It is hardly possible that they were heterogamous, for a highly differentiated oogonium would not be likely to return to conditions as simple as the primitive coenogamete. The gametangia of such isogamous algae as Cladophora and Codium present most nearly the structure demanded of the progenitors of the primitive coenogamete, but, of course, these forms are mentioned only as illustrations of conditions undoubtedly present in many groups of algae at various periods in their evolutionary history.

We can only speculate as to the manner in which a gametangium might become a coenogamete. The writer has already offered some suggestions on this point (Davis, 1900, p. 308), and he is more inclined to them since the recent studies of Harper (1900) and Stevens (1901) and the present investigation of Saprolegnia. We can readily conceive the derivation from isogamous algae of groups of aquatic fungi with terminal sporangia discharging motile gametes after the manner of Cladophora. Should such fungi leave the water and adopt terrestrial habits either as saprophytes (Mucorales) or as parasites (Peronosporales), certain changes in the sexual processes would be very likely to result. The gametangia could not form and discharge motile gametes excepting when wet, and would be compelled to adapt themselves to the aerial environment. They would be very likely to develop such unity of structure and behavior as is displayed in Pythium and Peronospora by those sporangia (conidia) which have given up the habit of forming zoospores and now germinate by a tube. The gametangium would become a coenocytic unit, with the chemotactic qualities and possibilities associated with sexuality. These chemotactic influences might be satisfied by the fusion of the gametangia (coenogametes) in pairs whereby the gamete nuclei would be able to unite two by two in a common protoplasmic medium. This process would take the place of the conjugation of motile gametes in water, and apparently satisfy all the hereditary demands as far as nuclei are concerned. The structure resulting from the fusion of these simplest coenogametes would be very similar to the zygospore of the molds.

Although there are no coenogametes among the algae, the sexual processes in the Conjugales have some features worth noting in this connection. In the desmids the gametes slip from the parent cells and fuse as naked masses of protoplasm. But in the filamentous Zygnemaceae and Mesocarpaceae the energids (gametes) remain in the respective parent cells which push out conjugating processes. The conjugating processes are surrounded by a cell wall so they are in every respect similar to the conjugating tube of Pyronema or the receptive papilla of the Peronosporales, excepting that they emanate from a uninucleate cell instead of a coenocyte. It is important to note that the conjugation processes in the Phycomycetes and Ascomycetes have their analogies in the algae, for it might be suggested that the development of such a structure by a coenogamete would be difficult. On the contrary, it seems the natural expression of any cell with chemotactic tendencies, whether uninucleate or multinucleate, to fuse with its neighbors. It is very probable that the development of such a conjugating tube in a coenogamete would be at the point where formerly the naked motile gametes were discharged, for that place is evidently the seat of important cytoplasmic activities.

To sum up our conception of the Phycomycetes, we must regard them as a group of several independent phyla. The Chytridiales in morphology and life-history are the lowest and resemble the algae at the level of the Protococcales. Monoblepharis, and probably several other isolated genera, seem most closely related to heterogamous algae. The Entomophthorales are too highly specialized to be easily derived directly from algal ancestry and need not be considered in this paper. There are left the most conspicuous of the Phycomycetes in three orders, that agree primarily in having either typical coenogametes (Mucorales) or sexual organs probably derived from coenogametes (Peronosporales and Saprolegniales).

These three orders, however, can only be related to one another through a common ancestry whose sexual organs were coenogametes. The Mucorales illustrate most completely the primitive coenogamete, and for this reason in part may be considered rather the lowest of the three groups. In the Peronosporales we have an ascending series from forms such as *Albugo Bliti* and *A. Portulacae* with true coenogametes, although more highly specialized than those of the molds, to the conditions in *Albugo candida*, Peronospora, and Pythium. This advance is evidently such an evolution as would provide a single uninucleate egg with the richest supply of food and best protective walls possible. In the Saprolegniales the evolutionary trend is similar in that a great many potential gamete nuclei are sacrificed to give a uninucleate egg, but we are not yet prepared to trace exactly the steps in the origin of this oogonium. However, the probabilities are that it, too, has come from a coenogamete, and that the segmentation of this protoplasm to form many eggs does not imply a derivation from heterogamous ancestry, but special peculiarities associated perhaps with the presence of several coenocentra. Oogenesis in Saprolegnia certainly indicates an ancestry with coenogametes. The Mucorales, Peronosporales, and Saprolegniales then probably come from a somewhat similar ancestry with coenogametes, which necessitates their derivation from isogamous algae at about such a level as is illustrated today by Cladophora and forms of the isogamous Siphonales.

We do not propose to discuss the phylogeny of the Ascomycetes further than to present its problem with respect to the coenogametes. The difficulty of relating the diverse sexual organs represented by Sphaerotheca, Pyronema, the lichens, and the Laboulbeniaceae has led to suggestions that the Ascomycetes are polyphyletic. But this view has many objections in the essential unity of the ascocarps and general rhythm of the life-histories throughout the group. Nevertheless, the various types of sexual reproduction seem very diverse when compared with one another and with conditions in the algae and other fungi.

However, should the coenogamete be established as a primitive type of sexual organ here as in the Phycomycetes, certain difficulties will be removed. The oogonium (archicarp) would be considered a development from the coenogamete along a well-established evolutionary line, that of numerical nuclear reduction. The evolutionary trend of the coenogamete would then be toward the uninucleate oogonium (Sphaerotheca) following the tendency of sexual evolution so well recognized in the algae. The groups of the Discomycetes and Pyrenomycetes would then readily arrange themselves according to the structure of the ascocarp and general vegetative complexity.

There would be left the lichens and Laboulbeniaceae, whose trichogynes at least suggest the Rhodophyceae, while in the latter group there are certain histological resemblances to this same group of algae. Granting these possible affinities, it is nevertheless very difficult to conceive the multicellular trichogyne as derived from the simple structure of the red algae. It must also be borne in mind that the structure of the ascocarp, especially among the lichens, gives no suggestion of a cystocarp, but, on the contrary, presents a structure identical with the fructification of other Ascomycetes. Were it possible for the coenogamete to develop a multicellular trichogyne (there is a multinucleate one in Pyronema) then evolutionary lines might be established that would lead very naturally into the lichens and Laboulbeniaceae. Such trichogynes would be another form of expression of this remarkable structure, the coenogamete, which is able to utilize superfluous protoplasm in such a variety of ways.

In this connection it is interesting to sum up the various ways in which the superfluous protoplasm of a coenogamete may assert itself. It may form a periplasm of importance in developing the spore wall (Peronosporales). It may form a surrounding tissue from such periplasm (Araiospora). It may develop a conjugating tube (Pyronema). And finally we suggest the possibility of multicellular trichogynes derived from coenogametes. While this cannot be more than a speculation, nevertheless cytological and developmental investigations among the lichens and Laboulbeniaceae in relation to these possibilities are sure to bring forth interesting results.

We may then conceive the Ascomycetes as presenting two important evolutionary lines derived from a primitive coenocytic type of sexual organ (coenogamete). The first, through numerical reduction of potential gamete nuclei, results in uninucleate sexual organs (Sphaerotheca). The second line supposes the utilization of such potential gamete nuclei with cytoplasm to develop such secondary sexual structures as the conjugating tube of Pyronema and the trichogynes and procarpic apparatus of the lichens and Laboulbeniaceae.

It is difficult to relate the account of Juel (1902) for Dipodascus to conditions in other coenogametes. Juel believes that there is but one sexual nucleus in each of these multinucleate gametes, the others being "vegetative;" that there is only one fusion nucleus in the fusion cell. This gives rise to a series of nuclei around which the spores develop in the sac and the "vegetative" nuclei degenerate. The details of the nuclear activities are not reported, and many stages in the processes are completely lacking. Until we know these we must hesitate to express an opinion on the position of Dipodascus.

THE NUCLEUS OF PHYCOMYCETES IN ONTOGENY.

A detailed and complete study of the nucleus of some Phycomycetes in the various phases of ontogeny is greatly to be desired. At present we know a good deal about the nuclear activities during gametogenesis and something at the time when the oospore germinates, but the data are not complete for any one form and do not explain the most important problems of ontogeny. These concern the significance of the mitoses in the gametangia, the relative numbers of chromosomes at different periods of ontogeny, and their bearing on the sequence of generations, which is not well understood in this group.

This knowledge will demand the study of one or more types with attention to nuclear phenomena during vegetative periods, especially at the time when asexual spores or conidia are formed, during gametogenesis, and during the mitoses following the fusion of sexual nuclei. Species of Albugo and Peronospora seem to offer the best material for these investigations. Pythium, although easy to cultivate and control, has nuclei so small that it is almost impossible to study such details. The same difficulties are met in the Mucorales and in part in the Saprolegniales, and in the latter group the complications of apogamy render the forms useless for these problems. Speculations on the reduction of chromosomes and the significance of various phases of ontogeny in this group are almost futile until we have convincing and complete data for one or more types.

Whatever may be the significance of the mitoses in the gametangia, there is no proof that they are reducing divisions, and it is probable that they are only phylogenetic reminiscences. Stevens's observations that the nuclei in the second mitosis of Albugo are much weaker in kinoplasm are interesting, but it is very questionable whether such divisions are necessary steps in the physiological differentiation of gametes. The mitosis may have simply a phylogenetic relation and the lessened kinoplasmic content be merely the result of that decrease in the size of the nuclei characteristic of advanced periods of oogenesis in these plants.

Everything seems to point to the ooplasm as trophoplasmic in character, first from the gathering of substance around the coenocentrum and second from the effect of this structure on nuclei in the vicinity. Staining reactions confirm this conclusion, but it is not wise to lay too much stress on the effect of stains in objects so small as these. And for this reason the judgment that the gamete nuclei are weak in kinoplasm must be taken with caution. The nuclei are generally smaller, and the conditions are such that the majority of them must disorganize; but the reason for this run-down state must be chiefly the general nutritive conditions of the gametangium, and not the mitoses of that period.

Stevens (1901, pp. 238, 239) lays stress on that period of oogenesis in Albugo and Perenospora termed "zonation," when the nuclei often in mitosis move from the center of the oogonium to the periphery. He suggests "that the nuclei pass to the periphery to rid themselves of superfluous kinoplasm, possibly to prevent parthenogenetic development of the oosphere." This theory seems to the writer to suppose an order of events and degree of preformed specialization more intricate than the evidence warrants. It seems more likely that "zonation" represents an event that happens to accompany, but is secondary to, those processes which gather the ooplasm in the center of the oogonium and give the egg its coenocentrum and characteristic alveolar structure.

Indeed, the conditions that cause that extraordinary degeneration of nuclei in the oogonium must furnish in large part the solutions of these problems. This phenomenon is universal, whether the nuclei break down in the eggs themselves (Saprolegniales), or are relegated to such secondary sexual structures as periplasm (Peronosporales) or a conjugating tube, as in the ascomycete Pyronema. As we have seen in Saprolegnia, the many nuclei in the eggs during advanced stages of oogenesis are all much reduced in size, and the only thing that saves the fortunate survivors of the general severe conditions is proximity to that center of metabolic activity, the coenocentrum. There is a limit to the number of nuclei possible in a given amount of cytoplasm. The nutrition of the oogonium decreases as oogenesis proceeds, and finally reaches a point when the nuclei are sorely pressed to maintain themselves. This certainly seems to be the history for the Saprolegniales, and probably every phycomycete whose sexual organs are coenogametes, as these structures are generally formed late in ontogeny, when the period of vegetation is about completed.

The nuclei are then subjected to a keen struggle for existence, and, in spite of the fact that they are in a symplast, which is itself a unit, they may well be supposed each to look after its own interest as far as possible. The outcome of that struggle is largely determined by the activities of the cytoplasm which may develop such metabolic centers (morphologically expressed by coenocentra) that certain nuclei by good fortune of favorable position are given great advantages over their neighbors and are finally selected as the survivors.

There are a number of instances known where sexual organs sacrifice some of their nuclei to provide the remainder with the cytoplasm at hand. Certain Fucales present notable examples, and there will probably be found other illustrations among the algae and fungi. Analogous conditions in animals have been reported, as in oogenesis of Actinosphaeria (Hertwig, 1898), and the well-known fate of supernumerary male nuclei in polyspermy. In these cases there has not been reported the same close relation between the surviving nuclei and metabolic centers of the cell as between the favored nuclei and the coenocentra of the Saprolegniales and Peronosporales. In this same connection we need more detailed accounts of oogenesis in the Fucales, Vaucheria, and Sphaeroplea.

The reasons why the oogonium overstocks itself with nuclei are probably phylogenetic and recall the time when numerous uninucleate gametes were formed from the protoplasm that now acts as a unit (coenogamete). Such uninucleate gametes were probably smaller than their homologues, the asexual zoospores, as is so characterstic of algae. Among the algae it is generally conceded that the small gamete swarm-spores result from different conditions of nourishment than their asexual homologues. It has been suggested that they are starved, but that seems a clumsy conception of very intricate processes. But there must be deep significance in the overproduction of sexual nuclei during gametogenesis and its obvious association with the deficient nutrition at the command of the gametangia. This phase of the subject has not received the attention it deserves.

SUMMARY OF THE INVESTIGATION OF SAPROLEGNIA.

OOGENESIS.

The material, *Saprolegnia mixta*, was apogamous, being entirely free from antheridial filaments.

The resting nucleus has a loose linin network and a nucleolus, and presents essentially the structure of the nucleus of higher plants.

There is one mitosis in the oogonium, the spindle being intranuclear. There are no centrosomes. The four chromosomes are derived from the linin network.

The daughter nuclei following the mitosis are much smaller than their parents. They shortly give evidence of coming degeneration, the nuclear membranes become indistinct, and the contents finally lie as granular material in clear areas resembling vacuoles.

The eggs are formed during the process of nuclear degeneration. The protoplasm in the oogonium at this period is arranged peripherally around a large central vacuole. The ooplasm collects around several centers, each of which is to become an egg origin. The egg origins are finally separated through the arrangement of vacuoles which results in the severance of connecting strands of protoplasm, and the eggs round themselves off as independent structures.

The differentiation of the egg origins takes place around a deeply stained protoplasmic body, the coenocentrum, from which delicate fibrillae radiate. The coenocentra are formed *de novo*, one for each spore origin. Each is at first a small globule, made conspicuous, however, by its fibrillar rays. It is most conspicuous in the young eggs, becoming less distinct with the ripening, and finally disappears. There is no trace of it in the oldest eggs.

The coenocentrum is a protoplasmic structure, but not a permanent organ of the cell. It is probably the morphological expression of dynamic activities in the oogonium when the egg origins are differentiated, and is a sort of focal point of the metabolic processes peculiar to oogenesis.

The coenocentrum exerts a chemotactic influence on any nuclei in its immediate vicinity. Generally one nucleus is selected and comes to lie very close to the coenocentrum, so that these two structures in the egg origins may be separated only under high magnification. This nucleus increases in size when all other nuclei in the egg origins and young eggs are degenerating, showing that it is greatly favored with respect to nourishment by its position near the coenocentrum.

Sometimes two or even three nuclei may lie sufficiently near the coenocentrum to be saved from degeneration, and such eggs are in consequence bi- or trinucleate. Binucleate eggs are not uncommon, trinucleate eggs are more rare.

As the eggs mature, the favored nucleus increases greatly in size, until it is many times larger than at the period following the mitosis. The other nuclei have generally completely disorganized, but sometimes traces remain as granules scattered in the cytoplasm.

Binucleate eggs in the Saprolegniales need have no relation to the problem of sexuality, and Trow's conclusions are not established.

SPOROGENESIS.

A general confirmation of the accounts of Rothert, Hartog, and Humphrey.

The uninucleate spore origins are differentiated by clefts that push their way from the central vacuole of the sporangium to the periphery. When the clefts reach the cell wall, the turgor of the sporangium is relieved through the escape of water, and the spore origins run together, but they soon draw apart and round themselves off as zoospores. There seem to be no cytoplasmic centers in the sporangium comparable to the coenocentra.

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NOTE.—Mr. Barker's interesting paper "The morphology and development of the ascocarp in Monascus" (Ann. of Botany 17: 167. 1903) came to my hand at the same time as the final proof of the foregoing article. I should have liked to discuss in detail a number of points which he takes up in connection with the origin and relationships of the Ascomycetes, but must defer the matter to some future time. There are some comments, however, which seem sufficiently important to justify this note. Monascus adds another form to the list of Ascomycetes whose sexual organs are coenogametes, and in so far strengthens my view that this type of sexual organ is likely to prove the primitive one for this group. I cannot agree with Barker that sexual conditions such as are presented in *Albugo Bliti* are simple enough for the lowest types of Ascomycetes, because the differentiation of ooplasm and periplasm, with the accompanying coenocentrum and the extreme specialization of the antheridium, all characters almost universal in the Peronosporales, are very much in advance of the sexual organs of Monascus, Dipodascus, and Eremascus.

Barker suggests that the egg of the Peronosporales may be cut out by a film of kinoplasm derived from the spindles of dividing nuclei at the period of oogenesis called zonation. He compares this free cell formation to sporogenesis in the ascus, in an attempt to relate the ascus to the zoosporangium through a gametangium which is homologous with the latter. Stevens and I studied carefully the origin of the egg membrane in Albugo and came to the conclusion that its formation has no connection with spindle fibers. In the first place, zonation is not universal among the Peronosporales; and again, it is largely a matter of chance that the nuclei are in mitosis at that time. Then too, the differentiation of the ooplasm is intimately connected with general dynamic activities of the cell, the same activities that develop the coenocentrum. Zonation is an incident to these more fundamental events. Ooplasm is dense or alveolar, while periplasm becomes very coarsely vacuolate because practically all of the large vacuoles are forced to the periphery by the accumulation of ooplasm around the coenocentrum. The plasma membrane which delimits the egg is formed around the dense ooplasm and becomes bounded by the large vacuoles outside. It is probable that this area of kinoplasm splits along a line of vacuoles between the ooplasm and periplasm and the cell wall is deposited between the two opposed plasma surfaces. These add secondary layers to both sides of the primary wall. The differentiation of the egg then bears no resemblance to the cutting out of ascospores by aster fibers, but on the contrary, recalls and agrees with the activity of vacuoles during the segmentation of the protoplasm in the sporangium of the molds, the oogonium of Saprolegnia, and the zoosporangium.

We are justified in emphasizing these details, since Barker lays stress on the zoosporangium as the possible homologue of the ascus. It should also be noted that the preliminary fusion of nuclei in the ascus is a peculiarity that cannot be lightly passed over in comparisons of this character, where agreement in cytological detail is absolutely necessary to establish homologies.

It is difficult to handle Dipodascus (Juel, 1902) at present because some details of nuclear activities are lacking both at fertilization and during sporogenesis. It seems probable that the development from the fusion cell, which is essentially a zygote, is sporophytic in character and may look forward to the formation of ascogenous hyphae and asci, in which case more information on the methods of spore formation is much to be desired.

The writer sees much in the conditions in Monascus and Dipodascus to support his view that the ancestral sexual organs of the Ascomycetes were coenogametes of the type illustrated by the molds; that the ascocarp is a sporophytic development entirely independent of possible analogous generations in other groups of fungi (*e. g.*, the so-called promycelium of *Phytophthora omnivora*); and that the ascus is a new form of sporangium, connected with a new generation, and only resembles earlier types (zoosporangium or the sporangium of molds) in such externals as are natural in structures developed terminally.

The evolution of coenogametes may then proceed along three or more divergent lines:

1. There may be the differentiation and utilization of a periplasm to assist in the formation of a thick walled resting spore which with the reduction of the gamete nuclei to one gives the line of ascent in the Peronosporales.

2. The segmentation of protoplasm in the gametangium around several coenocentra to form as many eggs, together with the gradual reduction of the number of gamete nuclei to one for each egg, presents conditions as in the Saprolegniales.

3. In the Ascomycetes superfluous protoplasm may be disposed of through a conjugating tube (Pyronema) or by a sterile cell (Monascus), processes which might lead to the development of trichogynes (lichens and Laboulbeniaceae); and besides these activities there is also the tendency towards nuclear reduction which results in uninucleate gametes (Sphaerotheca).

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EXPLANATION OF PLATES IX AND X.

The material, fixed in weak chrom-acetic acid, was cut 3μ thick and stained on the slide with safranin and gentian violet. All figures were sketched with an Abbé camera under the Zeiss apochromatic objective 2 mm. or 1.5 mm. in combination with compensation oculars. The magnification is as follows: Fig. 1, 250 diameters; Figs. 2–5, 12, and 13, 500 diameters; Figs. 6–9, 1,500 diameters; Figs. 10, 11, 14–29, 1,000 diameters; Figs. 30–35, 667 diameters.

PLATE IX.

(Figs. 1–15 illustrate oogenesis.)

FIG. 1. End of hypha about to form an oogonium.

FIG. 2. Young oogonium, nuclei approaching spirem.

FIG. 3. Central vacuole forming.

FIG. 4. Central vacuole; nuclei in spirem.

FIG. 5. More advanced than Fig. 4; nuclei in mitosis.

FIG. 6. Details of nucleus in spirem condition.

FIG. 7. Metaphase of mitosis; spindle intranuclear; nucleolus outside of spindle; three chromosomes shown.

FIG. 8. Mitosis just after the splitting of chromosomes at nuclear plate; nucleolus outside the spindle.

FIG. 9. Anaphase; two groups of chromosomes, four in each group, at the poles.

FIG. 10. Oogonium after mitosis with twice as many nuclei as previous to that event.

FIG. 11. Oogonium older than in Fig. 10; nuclei degenerating.

FIG. 12. Formation of egg origins under low magnification (500 diameters); coenocentrum in center of each egg origin.

FIG. 13. Egg origins older than in Fig. 12; coenocentra with conspicuous radiations.

FIG. 14. Coenocentrum before the differentiation of the egg origins; radiations plain; nucleus at one side of coenocentrum; other nuclei degenerating in the cytoplasm.

FIG. 15. Similar to Fig. 14; two coenocentra; nucleus at the side of each; many nuclei degenerating in the cytoplasm.

PLATE X.

(Figs. 16–29 illustrate oogenesis.)

FIG. 16. Egg origin just before rounding off to form egg; conspicuous coenocentrum with nucleus at the side.

Fig. 17. Young egg, nucleus larger than in Fig. 16.

Fig. 18. Young egg; coenocentrum without radiations.

Fig. 19. Egg, older than in Figs. 17 and 18; nucleus larger.

Fig. 20. Egg with nucleus extended toward coenocentrum, which has almost disappeared.

Fig. 21. Mature egg; large nucleus; coenocentrum disappeared.

Fig. 22. Young binucleate egg, the two small nuclei close to the smaller coenocentrum.

Fig. 23. Young egg with two coenocentra, each accompanied by a nucleus.

Fig. 24. An exceptionally large binucleate egg with prominent coenocentrum.

Fig. 25. Egg with two nuclei lying over one another, both extended toward the coenocentrum.

Fig. 26. Binucleate egg with the nuclei at a distance from one another.

Fig. 27. Binucleate egg with the nuclei close together.

Fig. 28. Trinucleate egg, the three nuclei lying close together.

Fig. 29. Trinucleate egg, the three nuclei at a distance from one another.

(Figs. 30–35 illustrate sporogenesis.)

Fig. 30. End of sporangium showing development of central vacuole.

Fig. 31. Portion of cross section of sporangium, central vacuole well developed.

Fig. 32. Early stage of segmentation; cleavage furrows running from central vacuole to periphery.

Fig. 33. After cleavage furrows have reached periphery, spore origins forming.

Fig. 34. Spore origins older than in Fig. 33.

Fig. 35. Zoospores in sporangium.

THE MACCHIE OF THE NEAPOLITAN COAST REGION.

J. Y. BERGEN.

(WITH FOUR FIGURES)

IT has occurred to the writer, after some two years of observation of the xerophilous shrubs and undershrubs of the territory surrounding the bay of Naples and of the islands of Ischia and Capri, that a brief account of this peculiar flora and of its conditions of existence might interest American botanists. Most of the literature of the subject is to be found in Italian botanical periodicals, or in monographs not readily accessible to the American student, and the vegetation in question is well worthy of study, since it constitutes a series of well-defined plant societies of a pronounced, though not extraordinarily xerophytic, character.

The soils of the mainland near Naples generally consist of weathered tufa, of decomposed volcanic scoria and pumice, or of disintegrated lavas of many kinds. Much decomposed vegetable matter is often present. As a rule the soils are deep, warm, and fertile loams, though occasionally feldspathic rocks are found to have been reduced by the action of steam impregnated with sulphur dioxide to a white clay, which is rather sterile. Yellow brick clays sometimes occur.

The soils of Ischia are in general not dissimilar to those of the mainland. Capri is underlaid by a moderately pure limestone, which outcrops in many places, but is usually covered with a somewhat shallow clayey loam, derived in the main from the decomposition of the subjacent limestone.

The climate in the neighborhood of Naples is characterized by mild rainy winters, during which there are few frosts at sea level, and long, hot, and dry summers. The greatest vegetative activity is therefore found in the months from October to May inclusive, and many annual plants complete their growth and blossom at some time during the period from November to April inclusive. Areas which are tenanted mainly by annual species or by herbaceous perennials, therefore, often present hardly any appearance of plant life during the drier months.

Outside of the many orchards and groups of walnut trees, together with occasional carefully preserved woodlands of small extent, the country is generally treeless. Thickets and considerable tracts covered with undershrubs form, however, an important feature in the physiognomy of the region, as they do of much of the Mediterranean coast, from Spain to Syria. These *macchie*, as they are called in the mainland of Italy and most of the Italian islands immediately about the bay of Naples, usually occupy small tracts of uncultivable land. These are often on steep hillsides, hilltops, or the flanks of mountains, at a height ranging from fifty to more than five hundred meters above sea level.

The plant societies of the macchie consist of many shrubby species, largely Leguminosae and Cistaceae. Most of the commoner species are indigenous, and a few, such as *Cistus salvifolius* L., *Daphne Gnidium* L., and *Euphorbia dendroides* L., are highly characteristic Mediterranean species.

The macchie of the island of Ischia consist of the following species and varieties:[1]

(1) Myrtus communis L.; (2) Pistacia Lentiscus L.; (3) Quercus Ilex L.; (4) Quercus pubescens Willd.; Phillyrea variabilis Timb. & Lor., (5) var. media L. and (6) var. angustifolia L.; (7) Arbutus Unedo L.; (8) Calycotome villosa Link.; (9) Cytisus triflorus L'Her.; (10) Cytisus monspessulanus L.; (11) Coronilla Emerus L.; (12) Spartium junceum L.; (13) Cistus monspeliensis L.; (14) C. salvifolius L.; (15) C. villosus L.; (16) Lonicera implexa Ait.; (17) Rosa sempirvirens L.; (18) Erica arborea L.; (19) Rhamnus Alaternus L.; (20) Daphne Gnidium L.; (21) Smilax aspera L., var. mauritanica Desf.; (22) Clematis Flammula L.

The list for the island of Capri is similar to that above given with the omission of numbers 5, 6, 10, and the addition of the following species:

Pinus halepensis Mill.; Smilax aspera L.; Quercus Cerris L.; Q. Aegilops L.; Thymelaea hirsuta Endl.; Phillyrea variabilis Timb. & Lor., var. latifolia L.; Euphorbia dendroides L.; Euphorbia spinosa L.; Rubus discolor W. & N.; Rosmarinus officinalis L.; Ulex europaeus L.; Calycotome spinosa Link.; Cytisus hirsutus L.; C. spinescens Sieb., var. ramosissimus Ten.; C. Laburnum L.; Colutea arborescens L.; Anthyllis Barba-Jovis L.; Ceratonia Siliqua L.

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[1] Slightly modified from the list given by GUSSONE, Enumeratio Plantarum Vascularium in Insula Inarime, p. X. Naples, 1854.

Several of these species are also found in Ischia, but as Gussone has not included them in his enumeration of the macchie of that island, I have not ventured to put them in.

On the mainland, from Cape Misenum to the end of the Sorrento peninsula, the macchie consist mostly of some combination of the elements found in the preceding lists. A partial idea of the numerical proportions of the species which compose these plant societies may be gathered from enumerations to be given in a subsequent paper on this topic.

A typical Neapolitan macchia does not usually contain half of the species comprised in either of the lists above given, and may even consist of but three or four species, as is the case on the flanks of Monte Nuovo, at the base of Cape Misenum. Here the undershrubs are so scattering as to give no appearance of a thicket, and are in general less than a meter in height. The prevalent species are *Spartium junceum*, *Cistus salvifolius*, *Pistacia Lentiscus*, and *Erica arborea*. In other cases, as in Capri, at the foot of Monte Solaro, near the so-called Baths of Tiberius, from the abundance of such large shrubs as *Arbutus Unedo* and well-grown saplings of *Quercus Ilex*, much of the thicket is not less than three meters in height. It is also, in this instance, peculiarly difficult to traverse, on account of the abundance of such climbers as *Smilax aspera*, *Clematis Flammula*, and the very prickly, herbaceous, trailing *Asparagus acutifolius*.

What Drude calls *Bestände*, and Hult, Kjellman, and others call "plant formations,"[2] rarely occur among the Neapolitan macchie. Arid mountain slopes sometimes show patches of Spartium almost unmixed with other undershrubs, and Cistus of a single species sometimes covers considerable areas, to the exclusion of other woody forms, but during the wet season many herbaceous plants occur intermingled with these species.

A large proportion of the shrubs which constitute macchie are evergreen, but some are winter deciduous and others are summer deciduous.

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[2] WARMING, Lehrbuch der ökologischen Pflanzengeographie, zweite Auflage. Berlin. 1902, p. 9.

Few areas can be found in which thickets are allowed to grow undisturbed. All of the shrubs which have much fuel value are cut to the ground and used for heating ovens and even for firing limekilns or kilns of tile or coarse earthenware.

It should be kept in mind that herbaceous vegetation flourishes vigorously among the macchie, during all but the driest months. A large proportion of the 700 species of phanerogams and vascular cryptogams which occur in Capri, of the 900 or more species of Ischia, and of the 1,000 or more of the mainland immediately surrounding the bay of Naples may be found among the plant societies which constitute the macchie of the region.

In attempting to look up the literature of the subject of this paper the writer has been impressed by the apparent lack of any moderately full bibliography of the topic. Much material of the sort exists, but it does not appear to have been systematically catalogued for the Neapolitan region, as it has been for other Mediterranean territory. A large number of titles will be found in Beck von Mannagetta's "Vegetationsverhältnisse der illyrischen Länder," pp. 25–45. Many are also given in Willkomm's "Pflanzenverbreitung auf der iberischen Halbinsel," pp. 23–27; but each of these books naturally refers mainly to the works which relate more or less directly to its own region.

The list at the close of this article, for which the author is indebted to his friend, Sig. Giovanni Ettore Mattei, librarian of the Royal Botanic Garden at Naples, contains some of the most important titles of works which will aid in the study of Italian macchie.

ENUMERATION OF PLANTS IN MEASURED AREAS.

In order to give a somewhat definite idea of the completeness with which the ground is covered in macchie of various types and of the relative abundance of different species, the author has counted the individual shrubs occurring in plots of ten meters square. The task of counting was no easy one, as in many cases each bushy clump had to be uprooted in order to ascertain whether it consisted of more than one individual. Of course single areas of no greater extent than a hundred square meters would in no case contain all the characteristic species of the macchie of a region, but the attempt was made, in every instance, to select fairly representative plots.

The following results were obtained:

A.

Capri, on northwest slope of Monte Solard, about 350 meters above sea level.

Name.	No. of Individuals.
Spartium junceum L. - - - -	106
Cistus villosus L. & *C. salvifolius* L.	603
Myrtus communis L. - - - -	15
Daphne Gnidium L. - - - -	4
Pistacia Lentiscus L. - - - -	1
Erica arborea L. - - - - -	1
Olea europea L. - - - -	1
Quercus pubescens Willd. - - -	1

The predominating shrub in this locality was the Spartium, leafless as seen in late summer. It occasionally reached a height of 1.5^{m}, with a spreading top. On the whole the macchia was scattered and open, most of the shrubs not much more than waist-high. The Cistus ranged from 0.2 to 0.5^{m} in height. At irregular intervals of fifty, one hundred, or more meters were scattered individuals of *Pinus halepensis* L. 2 to 4^{m} high, with thin foliage, which casts but little shade.

Although no specimens of any of them occurred in the plot just described, there are several species of undershrubs in the immediate vicinity which assume the pillow or cushion form (*Polsterpflanzen*) so common in some alpine floras. The most noticeable of these are *Cytisus spinescens ramosissimus*, *Euphorbia spinosa*, and *Satureia montana*.

B.

Capri, at foot of Monte Solaro (near stairs to Anacapri), perhaps about 130^{m} above sea level.

Name.	No. of Individuals.
Arbutus Unedo L.	464
Erica arborea L.	12
Quercus Ilex L.	12
Quercus Ægilops L.	12
Clematis Flammula L.	16
Smilax aspera L	200
Coronilla Emerus L.	812
Myrtus communis L	124
Cistus villosus L. & *C. salvifolius* L.	24
Pistacia Lentiscus L.	44
Rhamnus Alaternus L.	12

The shrubs in this locality formed a close and rather high thicket. Its denseness was in places at least twice that of the measured area *B*. The *Arbutus* was the predominating species from its large numbers and its size, some of the shrubs being 2.4^m high. The *Q. Ilex* in places reached the height of 4^m, but in general was somewhat over 2^m high. The *Coronilla* and the *Erica* showed themselves to be decidedly shade plants, reaching their greatest dimensions and appearing most vigorous when protected by the shade of taller species, *e. g.*, the *Arbutus*.

The much greater luxuriance of vegetation in *B* than in *A* is not mainly due to the lower altitude of *B*, but rather to the richer soil and better water supply. The soil of *A* was a thin layer of clayey loam, derived mainly from the weathering of the subjacent solid limestone, while that of *B* was of similar chemical and physical character, but deeper, and underlaid by a talus of small fragments of limestone (*fig. 1*).

C.

Pozzuoli, on exterior slope of Solfatara hill, facing S.E., altitude over 120^m above sea level.

Name.	No. of Individuals.
Myrtus communis L.	800–1200
Cistus salvifolius L.	190
Calycotome villosa Link	143
Erica arborea L.	42
Spartium junceum L.	33
Inula viscosa Ait.	27
Quercus pubescens Willd.	13
Quercus Ilex L. var.	10
Clematis Flammula L.	1
Arbutus Unedo L.	1

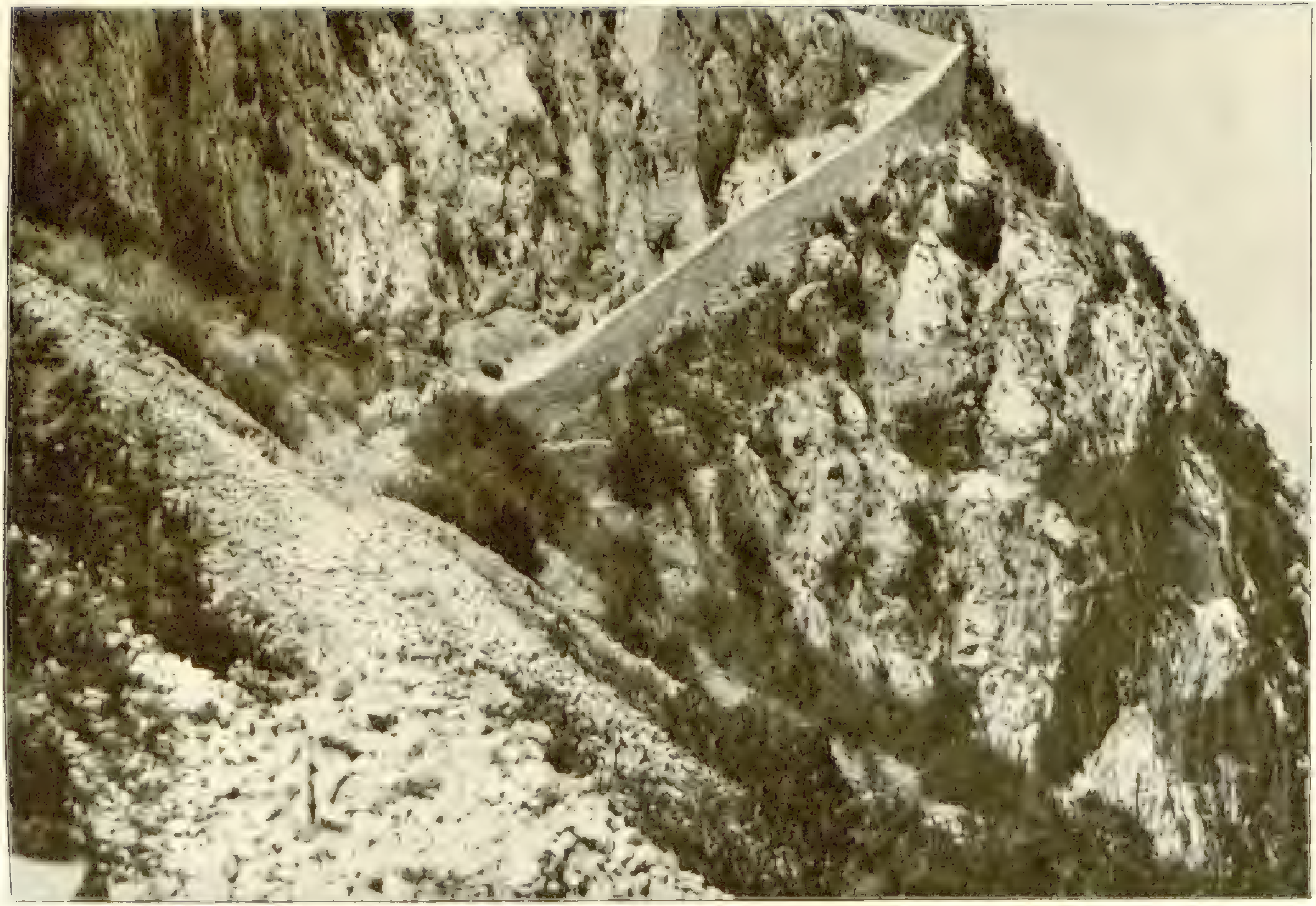

FIG. 1.—Macchia near stairs to Anacapri. Spartium formation in the center. At lower right hand, beginning of Arbutus macchia described under B.

This plot (*fig. 2*) was examined November 12, at which time the Arbutus and Inula were in blossom, the Myrtus and Clematis in fruit, and the other shrubs neither in flower nor in fruit. In numbers the Myrtus greatly exceeded all the other species combined, and indeed was in places so matted that it would have been impossible to count the individuals, without carefully digging up the entire mass and separating it into its factors. The number above given is therefore only an estimate. Most of the specimens were less than 50^{cm} and many only 20–30^{cm} high. The oaks were young growths from the stumps of saplings recently cut to the ground, and were therefore in no case more than 2^{m} high. The Calycotome appeared as a rapidly growing spiny shrub of 2^{m} or less in height, many of the specimens being seedlings of about a year old. The Spartium and the Inula each reached a maximum height of about 1.5^{m}; the latter a straggling undershrub, woody below, but with all the younger portions of the stems still herbaceous.

The Inula is not primarily a characteristic shrub of the macchie, but rather of the cliffside societies, but about Pozznoli it is a frequent companion of the shrubs in the list above given.

The soil of this locality was of volcanic origin, composed of finely divided ejecta from the crater of the Solfatara, with some of the feldspathic rocks decomposed by the action of sulfur dioxid into a white earth which is rather characteristic of the region. The mixture was porous and fairly warm, but by no means fertile.

D.

Monte Gauro, near Pozzuoli, east side of crater, west slope. Somewhat less than 200^{m} above sea-level.

Colutea arborescens L. - - - -	101
Spartium junceum L. - - -	22

E.

Monte Gauro, east side of crater, east (outside) slope. About 200^{m} above sea level.

Quercus pubescens Willd. - - -	32
Spartium junceum L. - - -	22
Crataegus Oxyacantha monogyna Jacq. -	11
Rubus discolor W. & N. - - -	8
Colutea arborescens L. - - - -	3
Clematis Flammula L. - - -	3
Cistus salvifolius L. - - - -	62

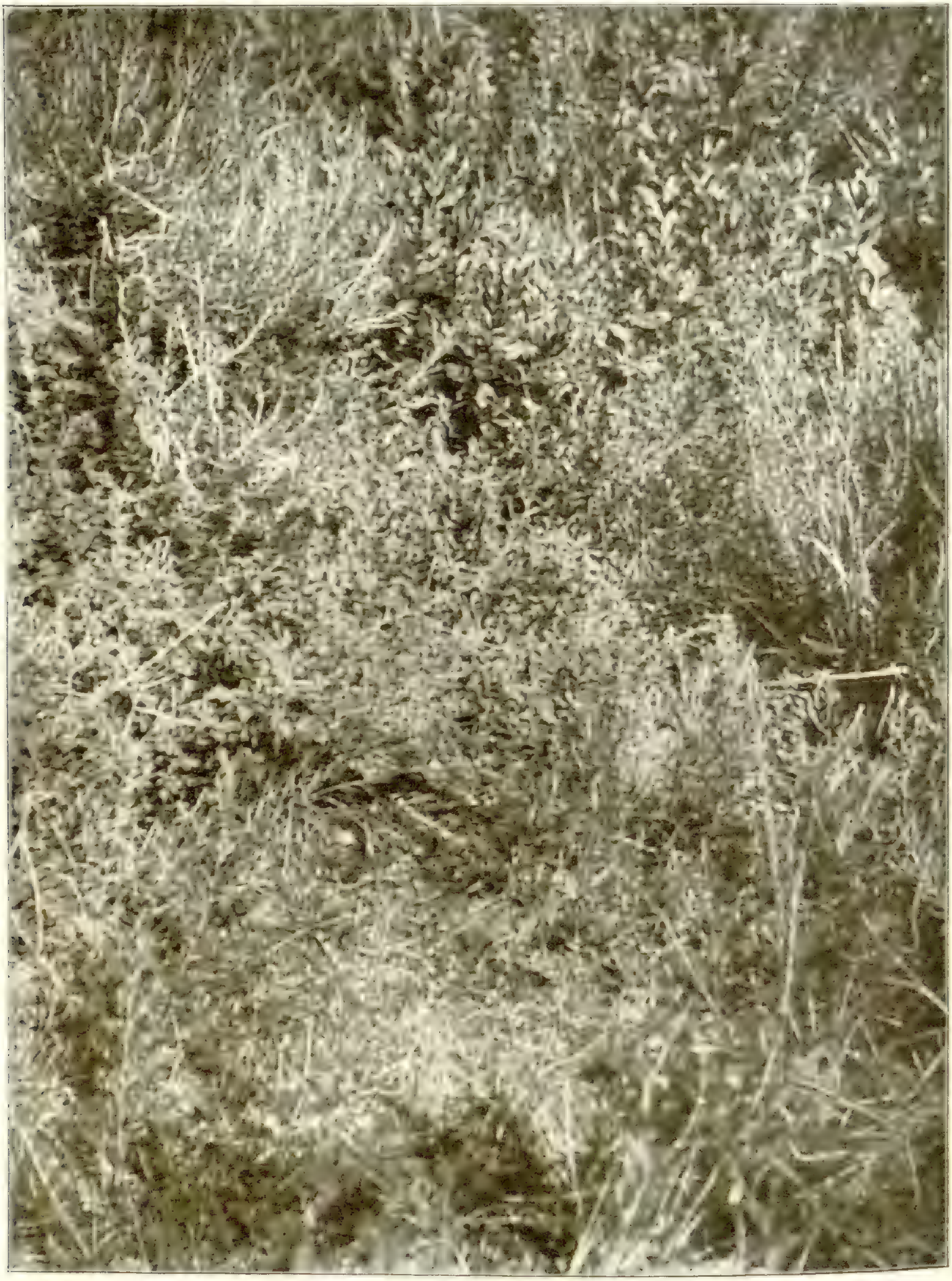

FIG. 2.— Macchia described under C, from exterior slope of Solfatara near Pozzuoli. Most of the broad leaved shrubs are Arbutus or Inula. The narrow leaved ones arc Erica.

The soil in both *D* and *E* was a rich loam, formed of decomposed tufa, deeper in the former locality than in the latter. The plant-society of *D* is a rather exceptional one, as the Colutea (here sometimes 2.5^{m} high) is a rare or local shrub. Large areas on Monte Gauro are, however, occupied by it, together with a few other species. Near the locality *D* but in scantier soil and more fully exposed to the sun were formations almost wholly composed respectively of *Pistacia Lentiscus* and of *Calycotome villosa*. At a lower level, in rich deep soil, was a consid-

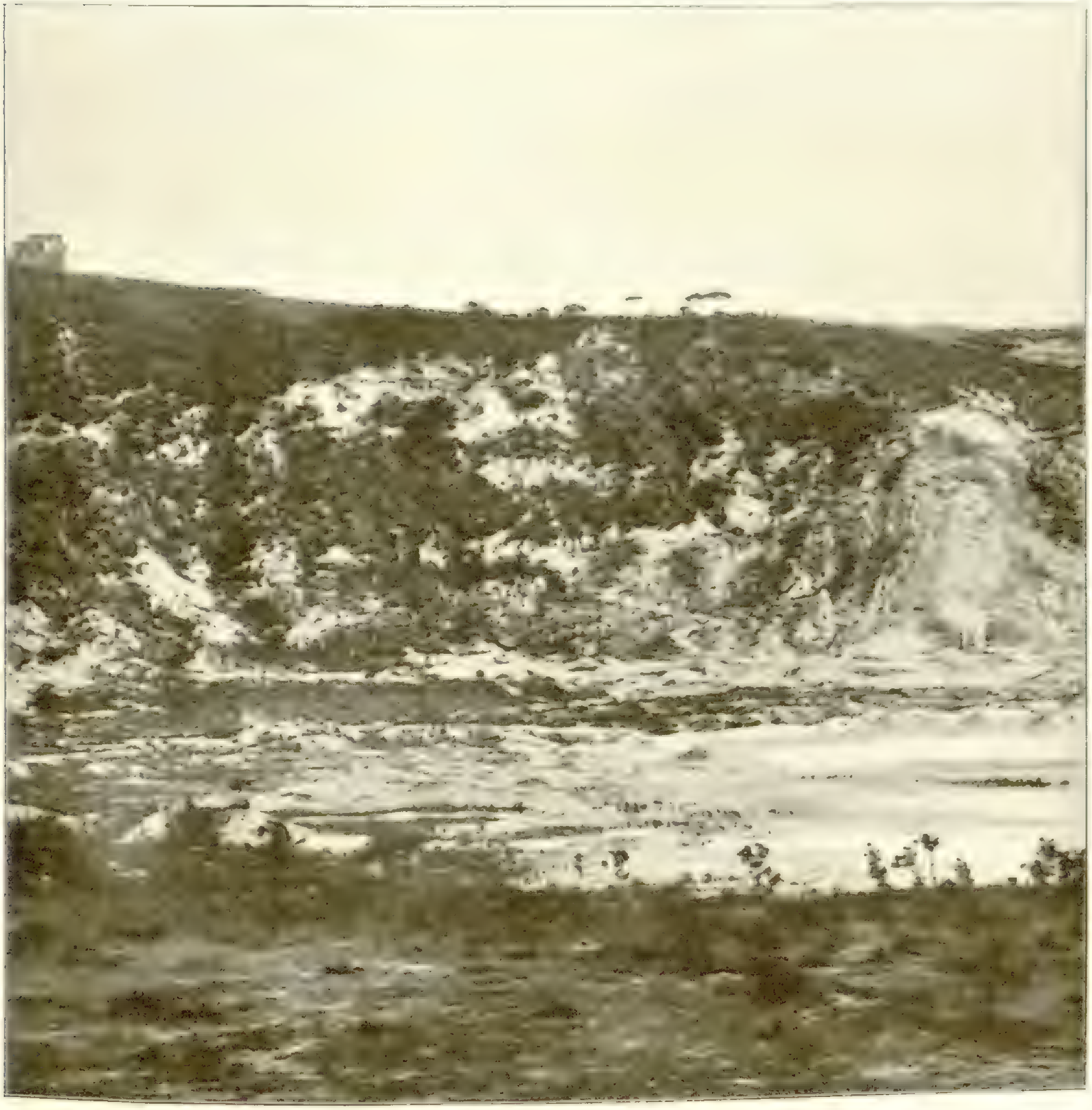

FIG. 3.—Interior of Solfatara near Pozzuoli, with macchia of Myrtus, Erica and Calycotome on north wall of crater.

erable tract covered with *Castanea sativa* Mill. (young saplings), and a shrub that appeared to be *Cytisus scoparius* Link.

The society *E* presented the aspect of a very open thicket, with the oaks predominating over all the other species, as many of them were about 3.5^{m} high. The Crataegus is not a common ingredient of the macchie about Pozzuoli, but frequently is encountered singly on the edges of banks, overhanging roads or cliffs. *Cistus salvifolius* when found growing among or under trees or tall shrubs, as in the societies *B* and *E* does not reach anything like its normal development, as, according to Beck (*op. cit.*, p. 126), it cannot bloom without receiving at least 0.23 of the total light intensity of the regions where it grows.

The areas *D* and *E* were measured and counted on December 20, and it is an interesting illustration of the indefiniteness of the seasons, and the imperfectly tropophytic character of the vegetation about Naples that the Colutea in many cases bore at the same time dry ripened pods, new leaves, old leaves, and a few flowers, although the regular flowering season is May and June. So too the Crataegus, which regularly blossoms in April and May, showed on December 20, in a few instances, new leaves, old leaves, blossoms, and ripe fruit on the same branches, This in spite of the fact that the winter of 1902 has been a cold one for the region, though without frost up to the date above mentioned.

In summing up the enumerations, it may be said that *B* and *C* are the most typical Neapolitan macchie, but the others are good examples of the way in which the grouping of species varies with soil, exposure, and other circumstances.

Side by side with the flora of the Neapolitan macchie there grows another (*fig. 4*), consisting, like the former, largely of woody plants, but for the most part distinct from it. I refer to the larger plants that partially clothe most of the cliff sides and many of the older tufa walls. The principal species are:

1. *Artemisia arborescens* L.
2. *Artemisia variabilis* Ten.
3. *Helichrysum rupestre* DC.
4. *Helichrysum litoreum* Guss.
5. *Achillea ligustica* All.
6. *Inula viscosa* Ait.
7. *Centranthus ruber* Dec.
8. *Spartium junceum* L.
9. *Medicago arborea* L.
10. *Opuntia Ficus-indica* Mill.
11. *Matthiola rupestris* Dec.
12. *M. incana* Dec.
13. *Satureia graeca* L.
14. *Euphorbia dendroides* L.

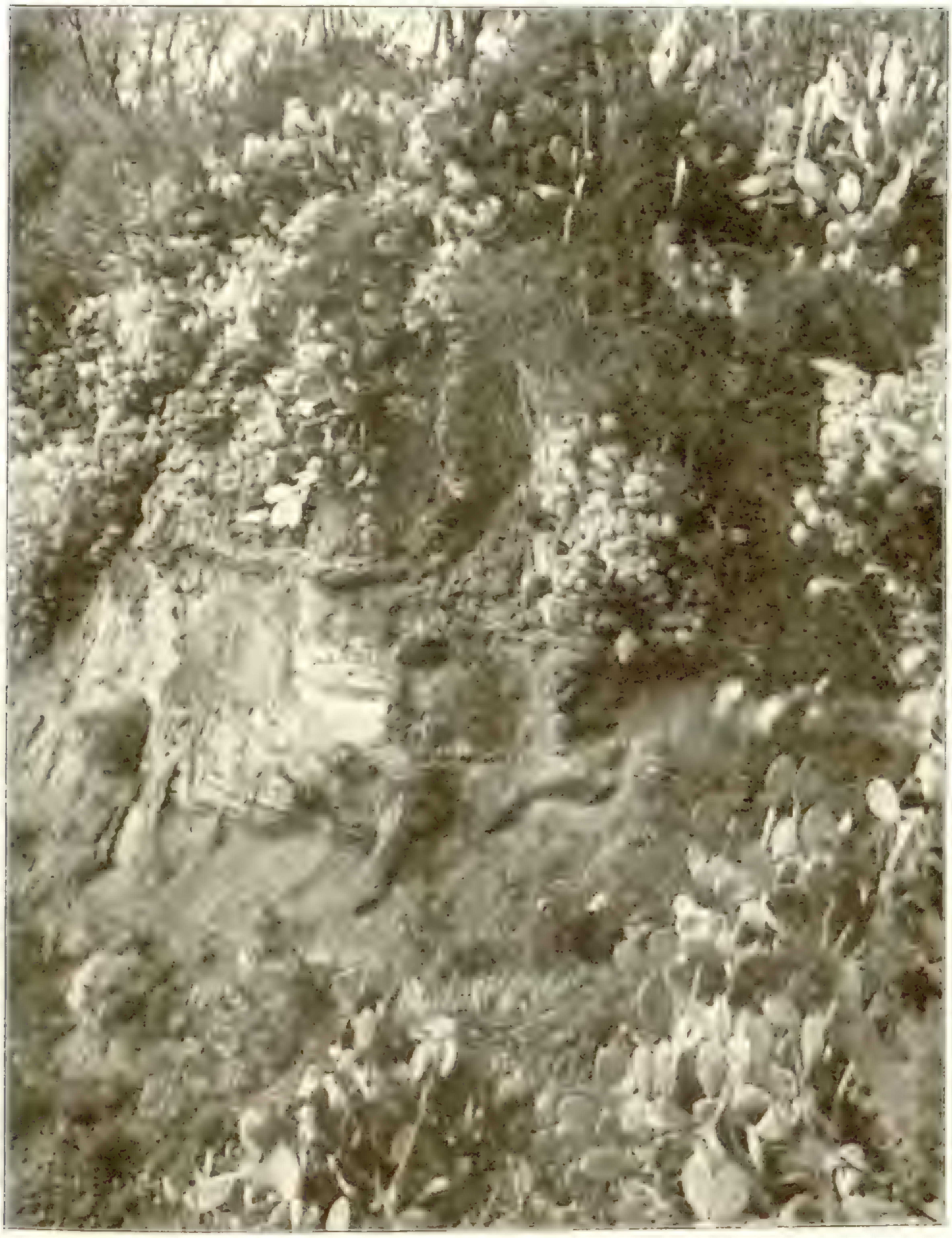

FIG. 4.—Flora of a nearly vertical cliffside at Pozzuoli. Suppose the cut to be divided into four equal vertical bands, numbered from left to right.

1. Top, *Olea sativa;* next, *Spartium junceum;* next, *Artemisia arborescens;* bottom, *Artemisia variabilis.*

2. Two-fifths distance from top to bottom, *Opuntia Ficus-indica* and *Matthiola incana.*

3. Top, *Pistacia Lentiscus* and *Asparagus acutifolius;* next, *Artemisia variabilis.*

4. Top, *Opuntia Ficus-indica;* next, *Artemisia variabilis;* next, *A. arborescens;* bottom. *Opuntia Ficus-indica.*

Of these plants only the Inula, the Spartium, and the Euphorbia are of common occurrence in the macchie. Generally speaking, all the species mentioned are much more xerophytic than their neighbors on more level ground. The Compositae (nos. 1–6) are all aromatic with essential oil; nos. 1, 3, and 4 are densely sericeous or tomentose, and nos. 3 and 4 have strongly revolute leaves, the margins almost meeting; no. 2 has fleshy, linear leaf segments, and no. 6 has pubescent varnished leaves. Of the remaining species, the Spartium and the Euphorbia are discussed in a later paragraph, the Opuntia (an introduced plant) is one of the most succulent of the genus, the Medicago has small pubescent leaves, and the Matthiolas are hoary pubescent.

(*To be concluded.*)

BRIEFER ARTICLES.

NUTATION IN BIDENS AND OTHER GENERA.

(WITH FOUR FIGURES)

THERE has long been a belief, regarded by many as a mere superstition, that the sunflower turns with the sun. In 1898[1] and in 1900[2] Schaffner published a series of illustrations and observations demonstrating conclusively that such a nutation exists. He makes no mention of any plant other than species of Helianthus that exhibit this

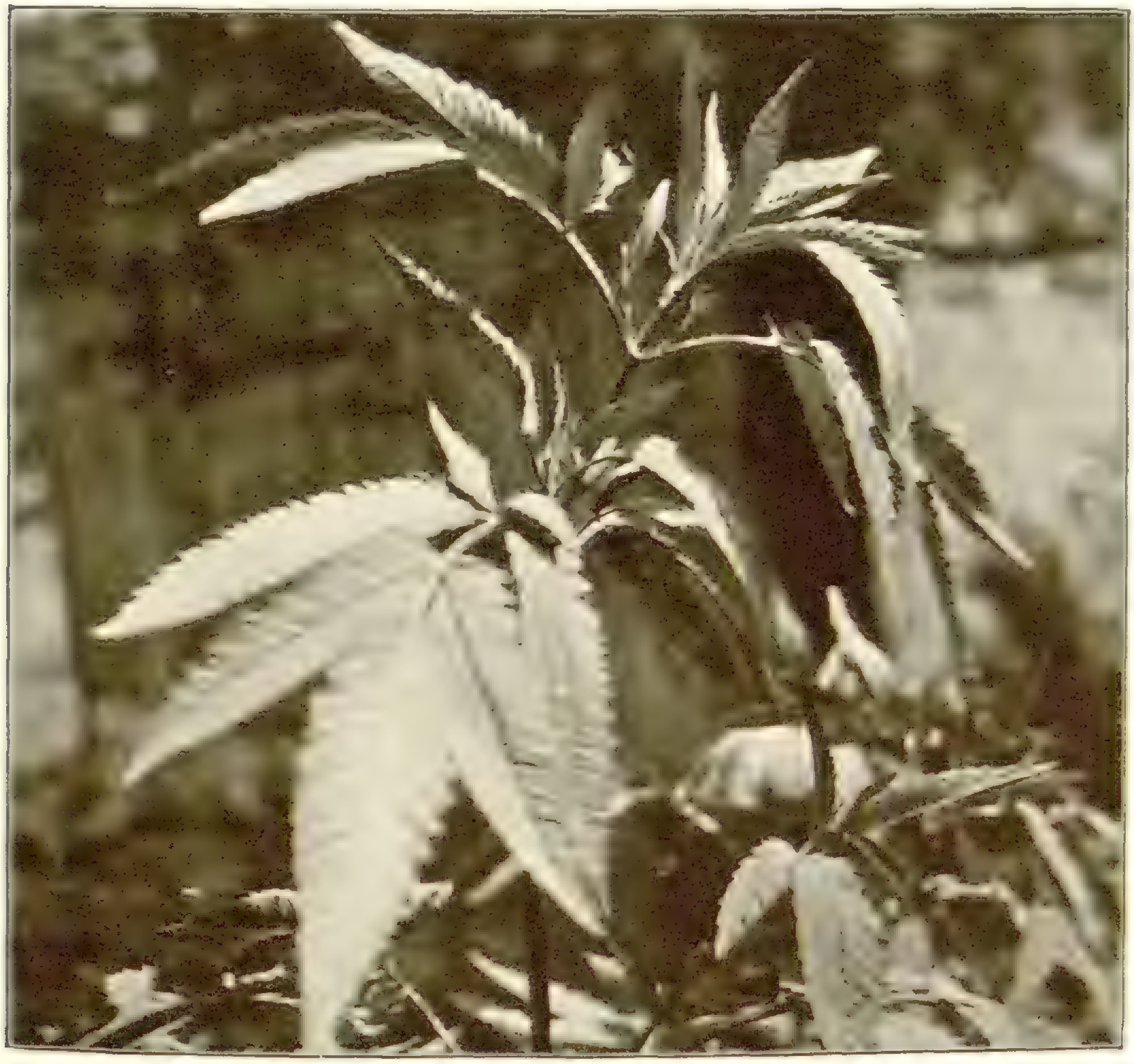

FIG. 1.— A single plant of *Bidens frondosa*. taken at 10 A. M., showing the eastward morning nutation.

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[1] Observations on the nutation *Helianthus annuus*. BOT. GAZ. **25**: 395-403. 1898.

[2] The nutation of Helianthus. BOT. GAZ. **29**: 197-200. 1900.

nutation, nor am I aware that any other plant has been observed to share with Helianthus the distinction of being a " sunflower."

During the past four or five years my attention has been repeatedly attracted to other genera that exhibited a diurnal motion almost identical in kind with that of Helianthus, and almost if not quite as marked. The accompanying illustrations of *Bidens frondosa* show the extent of the nutation in this species. *Fig. 1* shows one plant in the morning at 10 o'clock. The exposure occupied about one minute and it is evident that the curvature is not due to the wind, nor had the wind been blowing. I have repeatedly observed this same plant in the afternoon and found the westward nutation fully as marked as is the eastward in this illustration. *Fig. 2* shows a mass of plants of the same species in the morning, and illustrates the extent to which this habit preponderates among individuals. The same group taken at four o'clock the same afternoon is shown in *fig. 3*. This is simply a small portion of a roadside patch of weeds that extended for miles. Several counts showed that

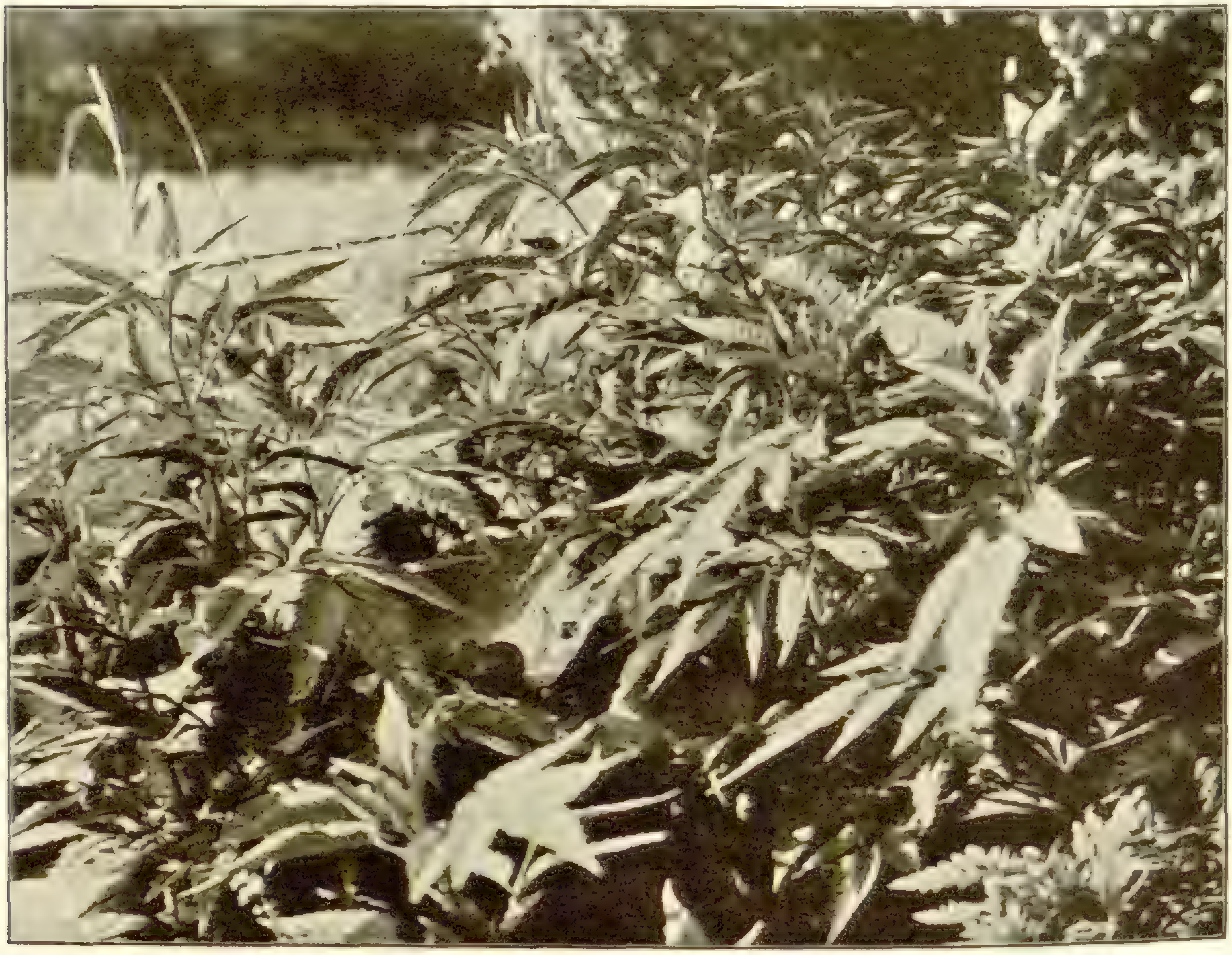

FIG. 2.—Group of *Bidens frondosa*, taken in the morning, to show prevailing eastward nutation (to the left).

between 95 and 98 per cent. of the individuals partook of this motion, some to a considerably more marked extent than others.

Agreeing with the observation of Schaffner for Helianthus, the nutation is much stronger when the ground is moist and the air warm and dry. *Fig. 4* is taken with the camera facing away from the sun, as is shown by the shadow of the camera itself near the lower left hand corner of the photograph. The almost universal sunward (westward) nutation here is strikingly shown. A photograph taken with the camera facing westward would have had the same general aspect if taken in the forenoon.

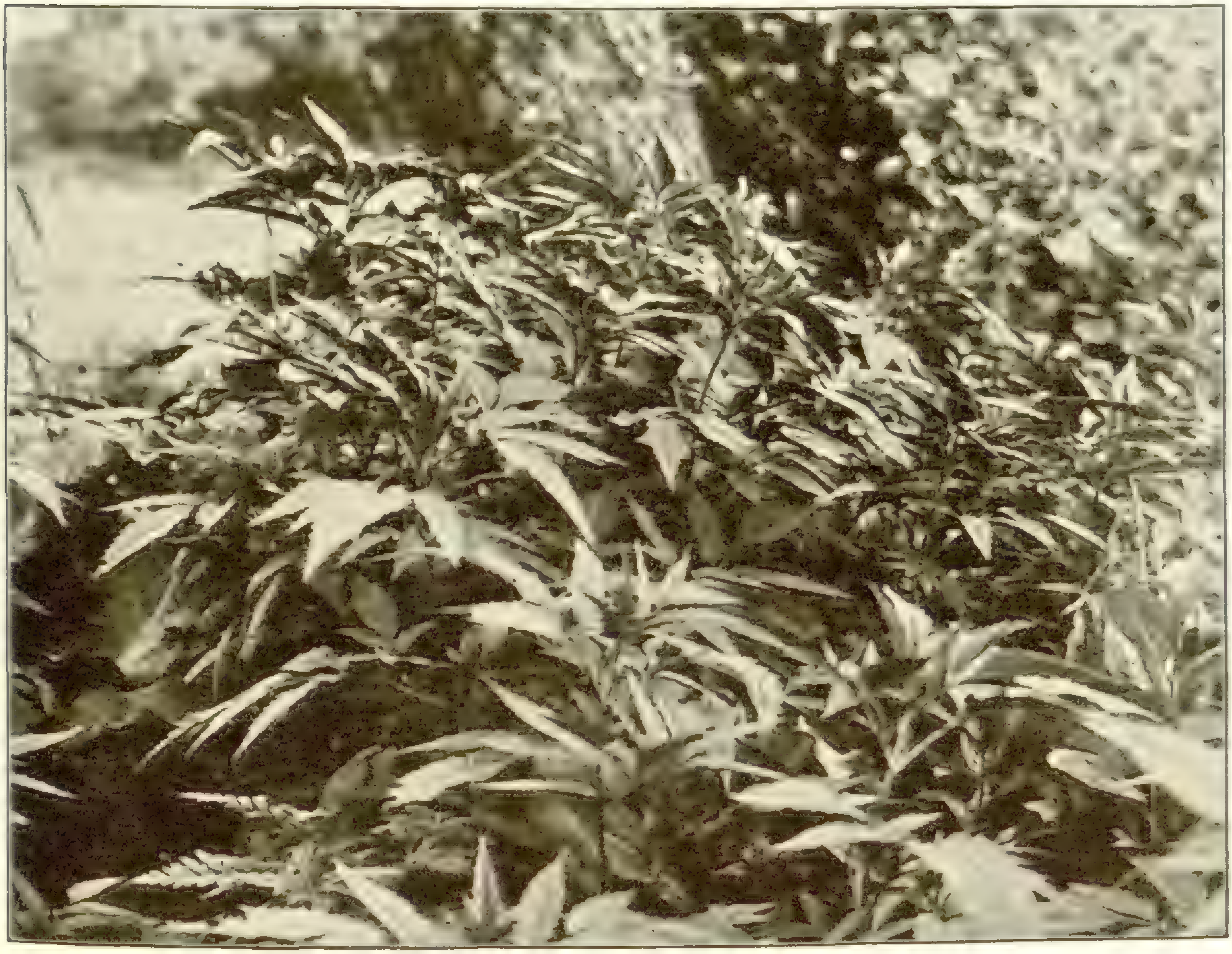

FIG. 3.— The same group shown in *fig. 2*, taken in the afternoon, to show strong westward nutation (to the right).

The nutation in *Ambrosia artemisiaefolia* is fully as marked as in Bidens, as I have determined by a large number of marked plants kept under observation during night and day. Some of these I have watched for many days, as they lay in my path to and from the class-room. Here the maximum eastward nutation is at about 9 A. M. Noon finds the stem erect, while at 7 or 8 P. M. the maximum westward nutation occurs. The plant begins to assume the erect position soon after sunset, and is usually quite erect by 10 or 11 P. M., and remains so until approaching sunrise.

Outside of the Compositae I find a nutation, though less marked, in Amaranthus, particularly in the younger plants, and in many of the Leguminosae. Doubtless it is to be found in many other families. Among the Leguminosae, Lespedeza, Melilotus, Medicago, and Trifolium are striking in nutation. *Melilotus alba*, for example, is particularly interesting, as the marked nutation strikingly affects the landscape as seen in going and returning from a day's drive.

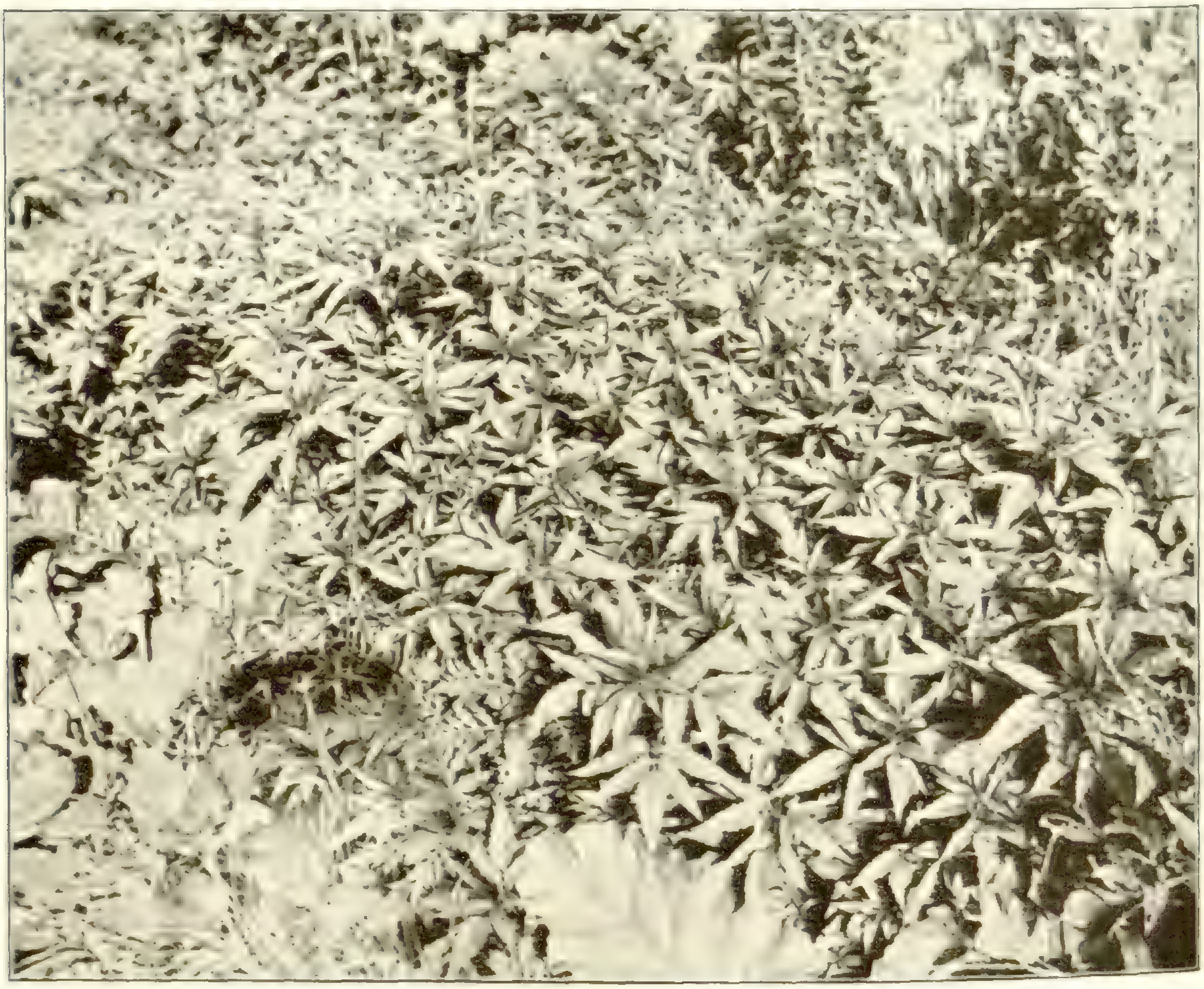

FIG. 4.—*Bidens frondosa*, taken with camera facing east. All plants facing the camera and the sun.

It is my purpose here simply to call attention to the diurnal bending or nodding of the stem. In addition to this there are of course very complicated changes in leaf position.—FRANK LINCOLN STEVENS, *Agricultural and Mechanical College, Raleigh, N. C.*

CURRENT LITERATURE.

BOOK REVIEWS.

Forestry and wood.

ALTHOUGH primarily a volume on forestry from the standpoint of political economy, the work by Fernow entitled the *Economics of forestry*[1] contains much that is of botanical interest. Under the heading, the forest as a condition, there is an excellent discussion on the influence of the forest upon the climatic conditions within its own limits and beyond. Emphasis is laid upon the fact that this influence is in no way comparable to the influence of the ocean, great air-currents, and extensive mountain ranges, but rather that the forest can modify only locally the effects of this general climate. The forest cover has a tendency to reduce the extremes of high and low temperature, but how far this difference is felt outside the forest has not yet been determined. The author holds that there is not, as yet, sufficiently reliable rainfall measurements obtainable to settle the question whether or not the forest influences the amount of rainfall. There are more reliable data, however, which show that as a wind-break the forest does modify the climate locally.

Other topics treated under the same general heading are the influence of forests upon the distribution and character of the water-flow, upon the mechanical conditions and erosion of the soil under cover, upon the health conditions, and upon the ethics of a people. In the chapter on the definition of forest and forestry one finds that forest knowledge is divided into three headings, viz.: the economic aspects (the condition), the technical aspects (the crop), and the business aspects (the revenue). The headings are ultimately divided into twenty-seven different branches, all of which are necessary to the comprehensive understanding of the subject.

In comparing forestry with agriculture the author says that in agriculture the factor of labor is most important, nature second, and capital last; in the forestry business the reliance on nature is greatest, on capital next, while labor plays a less important part. Nature unassisted has produced the virgin forest, but agricultural production is almost entirely dependent on human effort. To emphasize this difference it is shown that in Germany fifteen to fifty laborers are continuously employed on 250-acre farms as against one to three on the same acreage of forest.

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[1] FERNOW, B. E., Economics of forestry, a reference book for students of political economy and professional and lay students of forestry. 8vo. pp. xii + 520. New York: Thomas Y. Crowell & Co. 1902.

The chapter on the natural history of the forest contains an interesting discussion of the physical and biological relations of trees and forests. Other general topics treated are sylviculture, forest economy, forest policy, forest policies of foreign nations, forest conditions, and the forestry movement in the United States. The book is not intended as a popular discussion, but to supply a lack in the professional literature of economics in the English language. It is interestingly written and embodies so much general knowledge that it deserves to have a wide circulation.

UNDER THE general title *Wood*, Boulger[2] has collected in one volume many facts concerning both the scientific and commercial aspects of the subject. In the first chapter the origin, structure, and development of wood and the uses of wood are discussed. Then follows a comprehensive and valuable key for the determination of woods. Of more than usual interest is the treatment of the defects of woods, the selection, seasoning, storage, and durability of woods, the application of special woods, and supplies of wood. In part two is found an alphabetical list of woods, with facts concerning their sources, character, and uses.—H. N. WHITFORD.

MINOR NOTICES.

POSTELSIA[3] is a collection of seven botanical essays, four of which are phycological in character. The first is the *Uses of marine algae in Japan*, by K. YENDO. There are probably no people that make such extensive use of seaweeds as the Japanese. We are given a list of perhaps twenty-five forms that have a place in the life, principally of the peasantry, some as staple foods and others as delicacies, condiments, and decorative plants. There is even an extensive export trade, chiefly with China, for laminaria and agar-agar, which amounts to more than 30,000,000 lbs. a year. With each form is a brief account of its uses and the paper is illustrated with three Japanese prints. *Algae collecting in the Hawaiian Islands*, by JOSEPHINE E. TILDEN, is a very readable account of a summer spent among these islands, whose marine flora, rich in green and red algae, presents the sharpest sort of contrast to the luxuriant brown algae of the Pacific coast. Yendo has a second paper entitled *The distribution of marine algae in Japan*. He describes the varied ocean currents that bathe the Japanese archipelago and give to it such great extremes of temperature that a sub-arctic marine flora may be found almost side by side with a tropical. Japan with its bold shores and many bays and indentations furnishes wonderful variations in conditions, and will prove a magnificent field for a study of the factors that determine the distribution of algae. There is also a brief account of the marine laboratory at Misaki. The last essay is by Professor MacMillan on *The kelps of Juan de Fuca*. There are seventeen genera of kelps found in the Straits of Fuca, which is more than half of the total number in the Laminariales. The habits and many of the structural peculiarities of these are described in a popular style and illustrated with several excellent figures.— B. M. DAVIS.

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[2] BOULGER, G. S., Wood, a manual of the natural history and industrial application of the timber of commerce. 8vo. pp. viii + 369, *figs. 66. pls. 4.* London: Edward Arnold. 1902. $3.00.

[3] POSTELSIA. The Year Book of the Minnesota Seaside Station. 1901. 8vo. pp. 220. *pls. 26.* St. Paul: The Pioneer Press. 1902.

PROFESSOR MÖBIUS[4] has published in book form his laboratory dire tions for beginners. The book contains eighteen exercises, each intende to occupy about three hours. Directions are given for making sixty-five preparations, of which forty-two are phanerogams and twenty-three cryptogams. Almost without exception, the methods are those employed for examining fresh material, no microtome being used and almost no attention being given to imbedding or staining. In this country subject-matter like that contained in this book is usually presented by the teacher in the laboratory CHARLES J. CHAMBERLAIN.

NOTES FOR STUDENTS.

MONTEVERDE[5] states, in a preliminary notice, that protochlorophyll is not a yellow pigment, but is like chlorophyll in color and fluorescence. Etiolated leaves contain a certain amount of this substance, which begins to go over into chlorophyll as soon as these are brought into the light. In light, protochlorophyll is formed as fast as it changes into chlorophyll, and if green plants are placed in darkness this process sometimes continues until the green of the leaves is heightened by the accumulation of the former compound.— BURTON E. LIVINGSTON.

MOLISCH[6] finds the phosphorescent bacterium, *Micrococcus phosphoreus* Cohn, to be common and widely distributed instead of rare and sporadic as generally supposed. It is found upon meats in refrigerators and cold-storage houses, abattoirs, butcher shops, and kitchens into which flesh of slaughtered animals is regularly brought. To secure this species for study it suffices to dip a piece of fresh beef, veal, or pork into a 3 per cent. NaCl solution, to lay it in a dish half immersed in the same solution and keep it at 9–12° C. in a moist chamber. 89 per cent. of beef tested in this way showed luminescence. As the species dies quickly at the temperature of the human body it probably cannot be injurious if eaten. A revised description is given with illustrations.— C. R. B.

[4] MÖBIUS, M., Botanisch-mikroskopisches Praktikum für Anfänger. 8vo. pp. ix + 2. *figs.* 12. Berlin: Gebrüder Borntraeger. 1903.

[5] MONTEVERDE, N. A., Das Protochlorophyll und Chlorophyll. Bull. Jard. Imp. Bot. St. Petersburg **2**: 181–182. 1902.

[6] MOLISCH, HANS, Ueber das Leuchten des Fleisches, insbesondere todten Schlachtthiere. Bot. Zeit. **61**^{1}: 1–18. *figs. 5.* 1903.

THE PRINCIPAL points in our knowledge of the dendritic monocotyledons, together with some new observations, form the subject of a recent paper by Schoute.[7] On account of the slow progress of primary growth in thickness at the vegetative point, the stem is usually shaped like an inverted cone at the base, as in Pandanus; here prop-roots serve to support the stem. In the Liliiflorae, however, the inverted cone of primary growth is surrounded by a zone of secondary growth, giving the stem a cylindrical form at the base. Measurements of stems of Dracaena and other genera are given, which establish this point. Branches appear when apical growth is stopped by production of a terminal flower cluster; the growth of the branches repeats the process observed in the main stem.—M. A. CHRYSLER.

SCHUMANN has made an extensive comparative study of the ovulate flowers of the Coniferales (including Ginkgo).[8] Little attention is given to the earlier developmental stages, but the later stages and the mature flowers are described in great detail, and many suggestive comparisons are made. Teratology is not regarded as of much value in elucidating morphological relations or establishing homologies. Schumann finds that the Cupresseae are related to the Taxodieae, Sequoia being of living forms nearest the point of contact. This does not mean that Sequoia is the starting-point for the Cupressineae, but that the ancestral form must have been similar and related to Sequoia. This supports Potonié's theory that the Taxodieae appeared before the Cupresseae.—CHARLES J. CHAMBERLAIN.

IN A STUDY of the changes taking place in glucosides during metabolism, Weevers[9] finds that salicin is removed from the leaves of Salix to the bark in the dark and increases again in the leaves in light. Saligenol appears only in small quantities where salicin is decreasing in amount, quantities not large enough to account for nearly all of the salicin removed. There is found, however, an abundance of catechol in tissues from which the glucoside has disappeared, and in amounts sufficient to justify the supposition that salicin breaks down into glucose and catechol, saligenol being only an intermediate product. An enzyme active in this process could not be extracted, but it was found necessary to kill the tissues immediately in order to prevent a decrease in salicin content. Thus, the living protoplasm or a substance destroyed by boiling seems to be necessary. When glucose and catechol are produced, the carbohydrate diffuses away and the catechol remains and combines with glucose again when it becomes plentiful. Investigation of the changes in aesculin in germinating horse-chestnuts and of gaultherin in Gaultheria and Fagus were also made, but they are not yet as complete as the others.—BURTON E. LIVINGSTON.

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[7] SCHOUTE, J. C., Die Stammesbildung der Monocotylen. Flora **92**: 32–48. 1903.

[8] SCHUMANN, K., Ueber die weiblichen Blüthen der Coniferen. Verhandl. Bot. Vereins Prov. Brandenburg **44**: 5–80. 1902.

[9] WEEVERS, TH., Investigation of glucosides in connection with the internal mutation of plants. Kon. Akad. Wet. Amsterdam **1902**: 295–303. (Nov. 20.)

THE DEVELOPMENT of the spores in Selaginella has been investigated by Denke.[10] As is well known, Selaginella is a refractory object for cytological work. Denke recommends for fixing a mixture of one-third acetic acid and two-thirds absolute alcohol, and Haidenhain's iron-alum haematoxylin, with or without Congo red, for staining. He finds that the cauline sporangia originate from epidermal cells and underlying tissue. In the microsporangium a considerable number of spore mother cells fail to undergo the tetrad division. Such cells lose protoplasmic contents and function like tapetal cells. Microsporangia and megasporangia develop alike up to the spore mother cell stage and in phylogeny probably represent a common structure. In both microspore and megaspore mother cells the spindle is extranuclear in origin, and it appears while the nucleus is still in the resting stage. The spindle soon becomes bipolar and in its behavior recalls the spindle in the spermatogonia of the salamander. The formation of the membranes of the four young spores is peculiar, and, in spite of the attention which has been given to the subject, a conclusive account has not yet appeared. From the cytoplasm of the young spore, two membranes are formed one after the other. At first they grow in contact with each other, but the outer membrane by a more rapid growth becomes separated from the other, and a space appears between them. The inner layer—the mesospore—does not arise by a mere splitting of the outer layer, or exospore, as some have supposed. The delicate wall formed around each of the four young spores at the division of the spore mother cell is dissolved.—CHARLES J. CHAMBERLAIN.

GUIGNARD[11] has obtained some very interesting results from a study of *Hypecoum procumbens*, one of the Papaveraceae. Incidentally triple fusion was found to occur in the embryo sac, and the antipodals show that increase in size and prolonged activity characteristic of the antipodals of Ranunculaceae; but the chief interest centers in the unusual formation of the proembryo. The first division of the fertilized egg is transverse, as is usual, but by the enlargement of the basal cell the apical cell is thrust somewhat to one side and in this position divides at right angles to the first division. At first the two daughter cells of the second division are equal in size, but soon the upper one begins to enlarge, and becomes pyriform and approximately parallel with the origin basal cell. The three-celled proembryo thus consists of two large and inflated and presently vacuolate basal cells, lying side by side, and a small embryonal cell resting between them at their free ends. The two basal cells thus form a suspensor of most unusual origin, and remain very prominent and active during the slow development of the embryo, which is somewhat peculiar, in that it is not initiated by the longitudinal division of the embryonal cell, but by transverse divisions the embryo becomes

[10] DENKE, P., Sporenentwickelung bei Selaginella. Beihefte zum Bot. Centralbl. **12**: 182–199. *pls. 5*. 1902.

[11] GUIGNARD, L., La formation et le développement de l'embryon chez l'Hypecoum. Jour. Botanique **17**: 33–44. *figs. 21*. 1903.

a filament of four or five cells, whose apical and basal cells are the last to divide longitudinally.

The investigation traverses the account of Hypecoum given by Hegelmaier in 1878, and explains some of his inexplicable results, but at the same time introduces a proembryo and suspensor without precedent among angiosperms. The behavior of the suspensor cells after their formation resembles that found by Guignard among the Leguminosae.— J. M. C.

A RECENT PAPER read by H. Marshall Ward[12] before the Royal Society gives the results of a detailed study of the histological features of the germination, infection, and growth of the mycelium of *Uredo dispersa* in the tissue of grasses. The research has been prolonged and has involved thousands of preparations. The paper deals with the behavior of the nuclei, vacuoles, septa, branches, haustoria, and other details of the hyphae up to the commencement of spore formation.

The relations of the hyphae to the cell contents of the host are critically examined and the cumulative evidence not only fails to support Eriksson's "mycoplasm" hypothesis, but is completely subversive of it so far as histological facts are concerned. Eriksson's hypothesis, which refers the epidemic outbreaks of rust to the sudden transformation into the mycelial form of a supposed infective substance, previously latent and invisible in the cytoplasm of the host, is shown to be untenable because the *corpuscules speciaux* of this author are proved to be the cut-off haustoria of the fungus. Eriksson supposes that these *corpuscules* (haustoria) are formed by the hitherto latent germs in the host-cells, growing up in the cells into vesicles, which then pierce the cell-walls, and give rise to hyphae in the intercellular spaces. The present paper shows that Eriksson has entirely reversed the true order of events. The haustoria have been formed by the hyphae, and figures are given showing every stage in their development. The first haustorium may be formed by the infecting tube immediately after its penetration through the stoma, and figures are given showing the remains of the germ-tube outside a stoma, the swelling of its tip over the stoma into an appressorium, the passage through the stomatal cavity, and its development into a vesicular swelling whence the true infection tube arises, which latter may at once put forth a haustorium. In some cases all these latter phenomena are visible in one and the same preparation.— J. M. C.

NATHANSOHN[13] has recently made what seems to be by far the most important contribution to our knowledge of absorption and excretion which has yet appeared. Working with *Codium tomentosum*, he finds that when the plant is transferred from sea-water to a solution of $NaNO_3$, absorption of this salt occurs up to a certain limit, and then ceases. The limit of absorption seems to be determined by the concentration of the external solution, more solute being absorbed the more concentrated the latter is; but the process never continues until equality of concentration within and without the cells is even approached. This rule does not hold for sea-water, however, in which the alga accumulates $NaNO_3$ to a concentration of 0.02 per cent., although this medium contains only minute traces of the salt.

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[12] WARD, H. MARSHALL, On the histology of *Uredo dispersa* Erikss., and the "mycoplasm" hypothesis. Read March 12, 1903.

[13] NATHANSOHN, ALEXANDER, Ueber Regulationserscheinungen im Stoffaustausch Jahrb. Wiss. Bot. **38**: 241–290. 1902.

Further than this, if the alga be placed for a day in a 5 per cent. solution of $NaNO_3$, and then be transferred to a 3 per cent. solution of the same salt, absorption occurs in the stronger solution until the limit for that solution is reached, but after the transfer $NaNO_3$ is lost by the cells until the internal concentration has fallen to the limit for the weaker solution. Since the limit of absorption, even for the stronger solution, lies far below 3 per cent., this outward passage of the salt takes place from a lower to a higher concentration, and therefore in the direction opposite to that in which it should move according to the principles of diffusion of solutes.

The cells contain a large amount of NaCl when taken from sea-water. This salt diffuses outward in $NaNO_3$ solutions until a certain minimum of internal concentration of NaCl is reached, and this minimum limit is lower, the weaker is the external solution of the other salt. The internal concentration of the chlorid never even approaches its external concentration; thus this stoppage of outward diffusion of NaCl is parallel with the cessation of absorption in the case of the nitrate. There is no evidence of accumulation of either salt in the protoplasm, neither is the solubility of either salt different in the cell sap from its solubility in sea-water.

Further, if Codium plants be placed in a solution containing both $NaNO_3$ and NaCl (the latter salt being always of the same concentration, while the former is varied in amount), diffusion of the chlorid takes place either outward or inward according to the concentration of the nitrate without. Thus, if the concentration of $NaNO_3$ is 1 per cent. the plant loses chlorid; if it is 2 or 3 per cent., chlorid is absorbed, and this diffusion occurs whether the chlorid is moving with or against its diffusion tension. The usual principles of diffusion seem not to apply here at all.

This is the first unquestionable evidence that the living membrane in plants can overcome the osmotic pressure of a solute and cause its movement from lower to higher concentration. The phenomenon has been known in animals, however. The paper contains a large amount of suggestive theoretical discussion.—BURTON E. LIVINGSTON.

NEWS.

Professor Dr. E. Heinricher, of the University of Innsbruck, will depart for Buitenzorg, Java, in the autumn.

Dr. Oscar Emmerling has been promoted to an associate professorship of botany in the University of Berlin.—*Science.*

The title of professor has been conferred upon Drs. Gustav Lindau, Paul Hennings, and Carl Holtermann, of Berlin.

Professor W. A. Setchell, of the University of California, will spend next year in Europe in botanical investigation and travel.

Professor Volney M. Spalding, of the University of Michigan, has been given a year's leave of absence, which he expects to devote to travel abroad.

Dr. Michael Woronin, member of the Academy and professor of botany in the University of St. Petersburg, died recently at the age of seventy-five years.

Professor John M. Coulter, head of the Department of Botany in the University of Chicago, will travel in Europe during the summer and autumn. He sails with his family on May 23.

Dr. A. Ginzberger has been promoted to the position of adjunct in the Botanical Museum and Garden of the Imperial University of Vienna. Dr. O. Porsch has been appointed assistant in the same institution.

Mr. A. D. Selby, botanist to the Agricultural Experiment Station at Wooster, Ohio, who has been in residence at the New York Botanical Garden since December, has been granted a research scholarship of the Garden.—*Science.*

Professor R. E. Smith, assistant in botany at the Massachusetts Agricultural College and Experiment Station, has accepted the position of pathologist and assistant professor in botany in the University of California.—*Science.*

Filibert Roth, formerly assistant professor of forestry at Cornell University, and later chief of Forest Reservations in the Department of the Interior, has been appointed professor of forestry in the University of Michigan.—*Science.*

In the new appropriation to the U. S. Department of Agriculture, $674,930 have been granted to the Bureau of Plant Industry, an increase of

$62,200, and to the Bureau of Forestry $350,000, an increase of $58,140 over last year.

MR. CHARLES A. DAVIS, instructor in forestry in the University of Michigan, has been engaged to prepare a map showing the distribution of forest trees and soil relations for the Ann Arbor sheet of the topographic atlas soon to be published by the United States Geological Survey.—*Science.*

OTTO JAAP, of Hamburg (Mittelstr. 67) has undertaken the publication of *Fungi Selecti Exsiccati*, consisting of new or rare species in series of twenty-five numbers, with printed labels. Heteroecious species are to be represented in their different forms under the same number. The first series consists of forty-two pockets, representing twenty-five species.

THE RANKS of mycologists have suffered an irreparable loss in the death of Dr. A. N. Berlese, which occurred on January 26 at Milan, where he was professor of plant pathology in the Agricultural College. Although only thirty-eight years of age, his name has become well known to the scientific world on account of his extensive work in mycology and plant pathology.

MR. THOMAS HOWELL, editor of the *Flora of the Northwest* and a veteran collector in that region, has been appointed for the coming year field collector and curator of the herbarium for the University of Oregon. He has donated his herbarium to the University. It contains specimens from Oregon, Washington, Idaho, and Alaska to the number of ten thousand or more, many of them being types.

THE MICHIGAN ACADEMY OF SCIENCE, at its recent meeting held in Ann Arbor, elected among its officers for the ensuing year the following botanists: as president, Dr. Frederick C. Newcombe, University of Michigan; as secretary, Dr. James B. Pollock, University of Michigan; as vice-president of the section of botany, Professor B. O. Longyear, Michigan Agricultural College; as vice-president of the section of agriculture, Professor W. J. Beal, Michigan Agricultural College.

M. ÉMILE BESCHERELLE, honorary chief of division of Ministry of Public Works in France, died on February 26 in the seventy-sixth year of his age. For a long time he has devoted his leisure to the study of mosses, in whose taxonomy he had become an acknowledged authority. He had been for some years in feeble health, but continued work to the last upon a *Sylloge*, in which he intended to include all the diagnoses of new species published by him from 1862 to 1902. He had been president of the Botanical Society of France and was corresponding member of the Muséum d'Histoire naturelle, to which establishment he has given his type specimens.

PROFESSOR H. L. BOLLEY, botanist of the North Dakota Agricultural College and Experiment Station, has been appointed special agent for the investigation of the flax crop and flax diseases in Europe. Mr. Bolley will sail the first of June, spend some time in the Netherlands, and then proceed to eastern Russia, where an extensive study will be made upon the Russian crop, with a view to procuring types of seed which will be valuable for experimental tests in this country. As Agricultural Explorer he hopes to visit all the chief flax-producing regions and to learn much which may be of use to growers in this country. He has already contributed to the promotion of this industry by his investigations. Leave of absence has been allowed by the College, to which he will return.

DR. N. L. BRITTON, director-in-chief of the New York Botanical Garden, and Mrs. Britton returned from Cuba on April 4. During the brief visit made to the island a large collection of herbarium specimens was made, principally from the region around Matanzas, and some desirable specimens were brought back for the conservatories. Valuable assistance was rendered by Mr. John Shafer, curator of the herbarium of the Carnegie Museum, Pittsburg. In addition to the great amount of material secured which will be of great value in the continuation of investigations upon the flora of the West Indies, Dr. Britton was so fortunate as to secure a number of rare botanical books not previously in the library of the garden. Mr. Percy Wilson, museum aid, returned from Honduras March 18, bringing a large collection of living and prepared specimens of plants from the region near Puerto Sierra and Puerto Cortez.—*Science.*

THE DESERT BOTANICAL LABORATORY of the Carnegie Institution will be located at Tucson. Mr. Frederick V. Coville and Dr. D. T. MacDougal, the advisory board of the laboratory, after an examination of the deserts of Texas, New Mexico, Arizona, California, Chihuahua, and Sonora, reported in favor of locating the laboratory near Tucson, and the executive committee of the Carnegie Institution has approved the selection. The building is to be located on the shoulder of a mountain two miles west of the city. This mountain and the adjoining mesas bear an abundant representation of characteristic desert plants. The officers of the University of Arizona and of the Arizona Agricultural Experiment Station have taken a lively interest in the project. The Tucson Chamber of Commerce expressed its appreciation of the importance of the enterprise by donating the site and installing water supply and electric connections, beside rendering other valuable assistance. Plans for the building have been approved, and construction will be begun as soon as the site is prepared. It is expected that the laboratory will be ready for operation about September 1, at which time Dr. W. A. Cannon, the resident investigator, will take up his duties.

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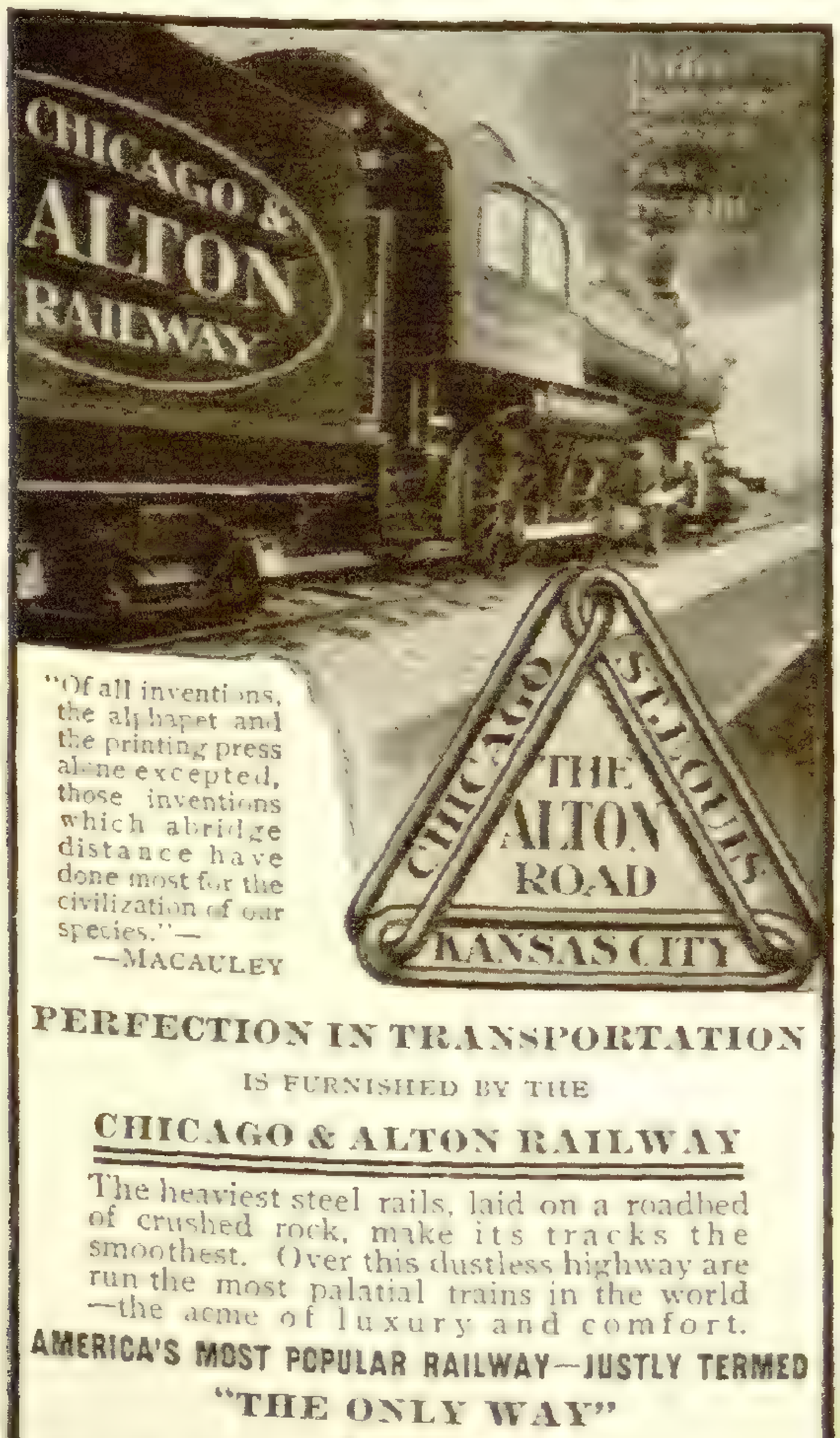

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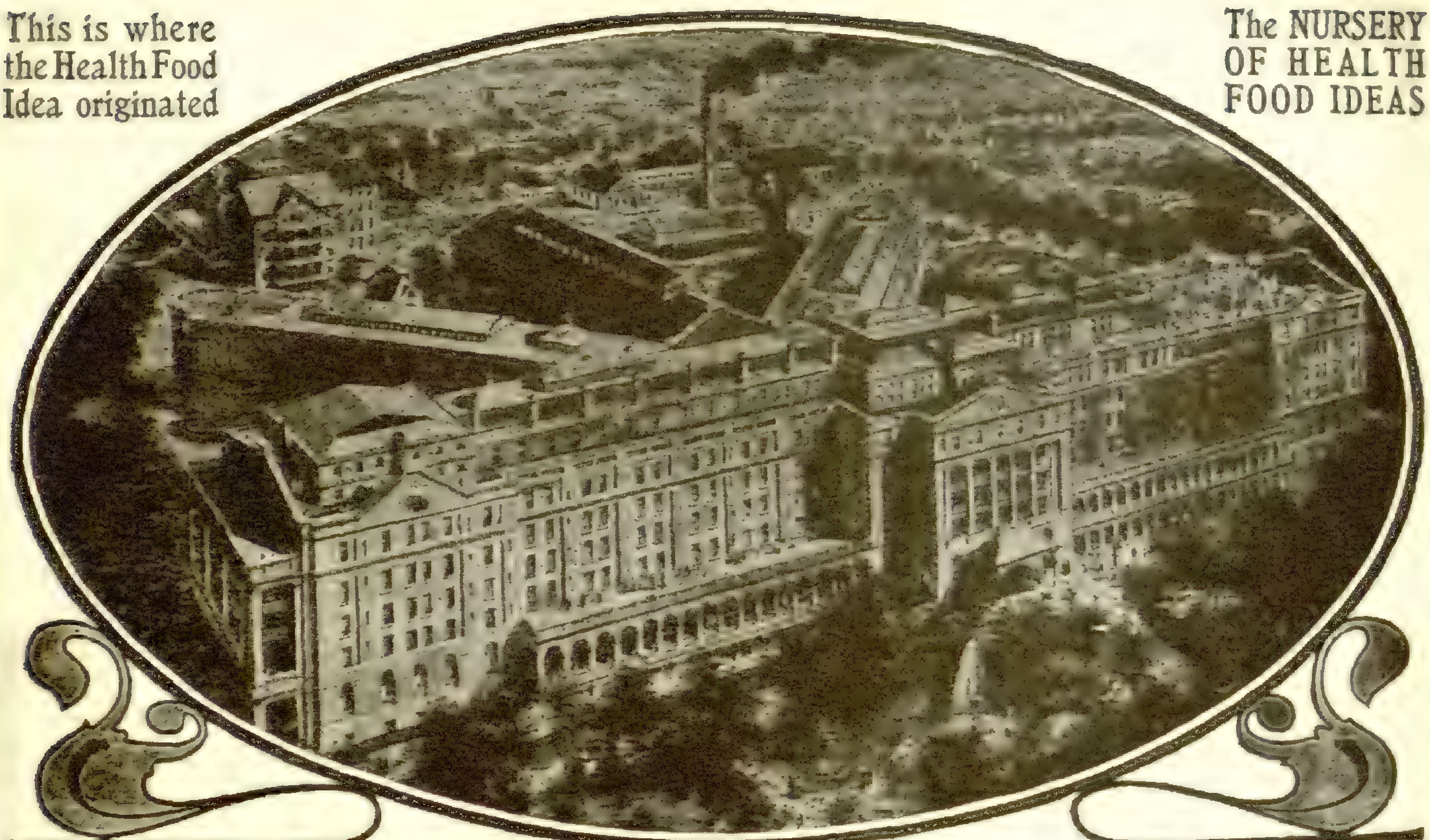

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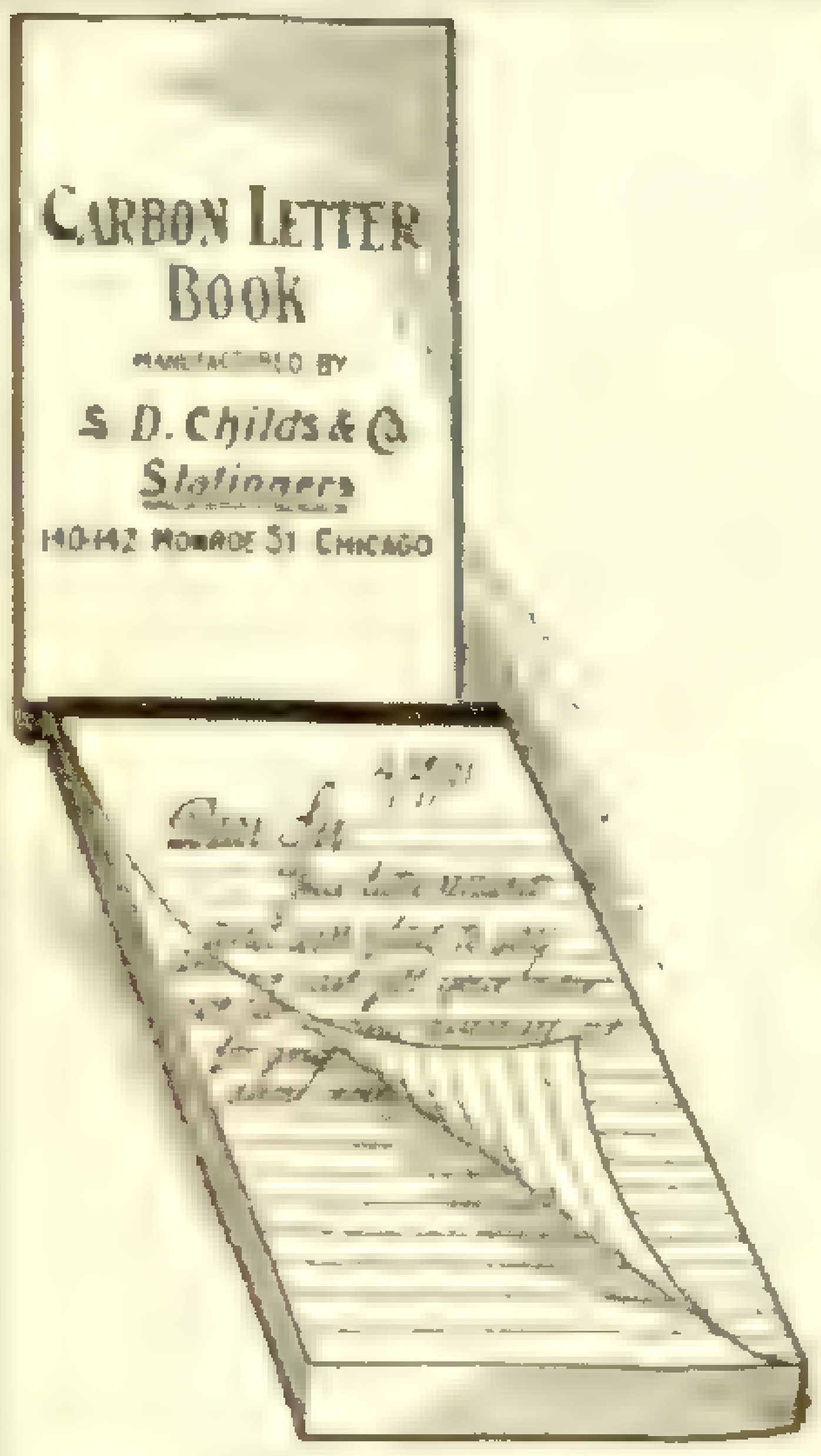
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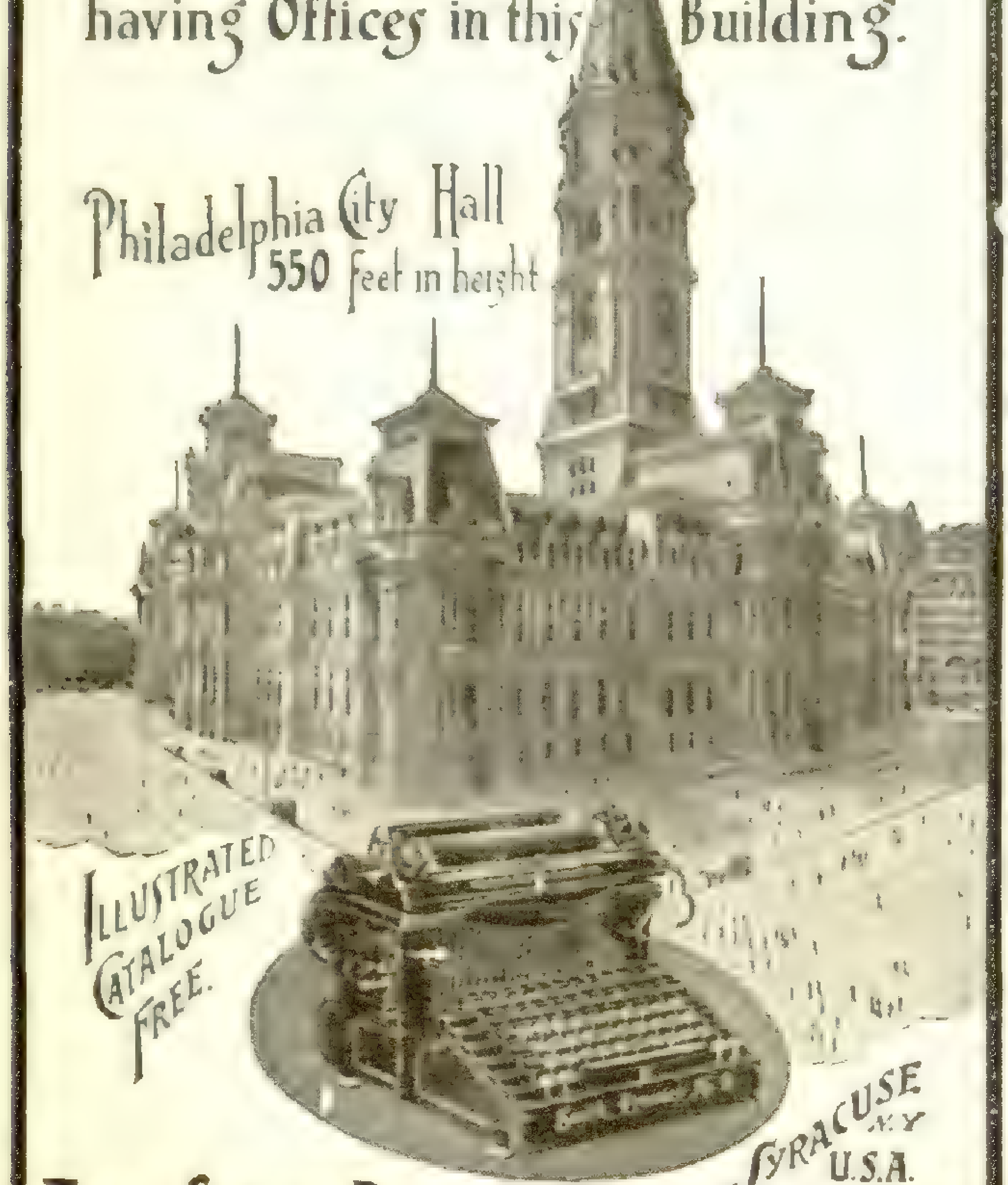

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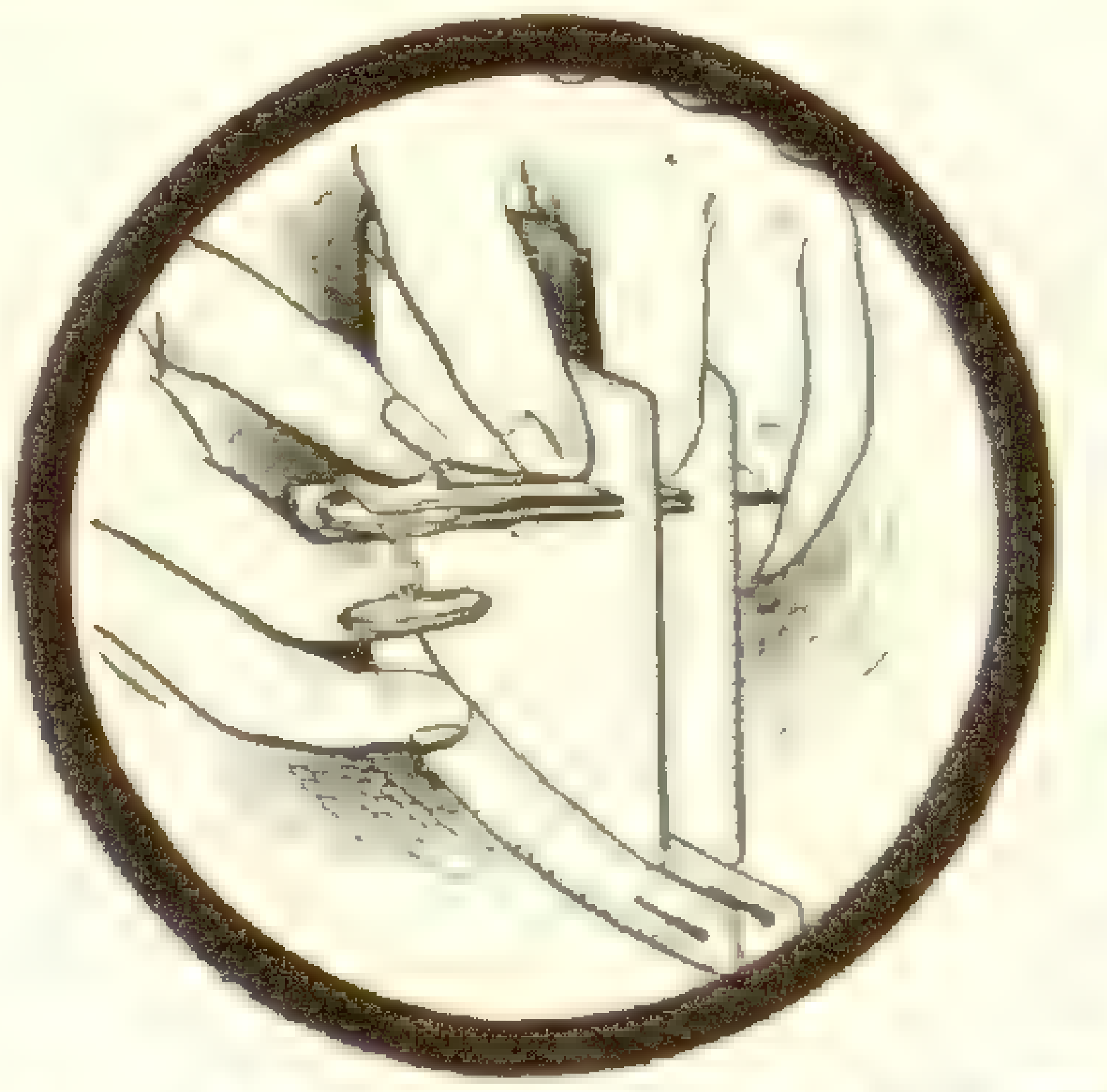

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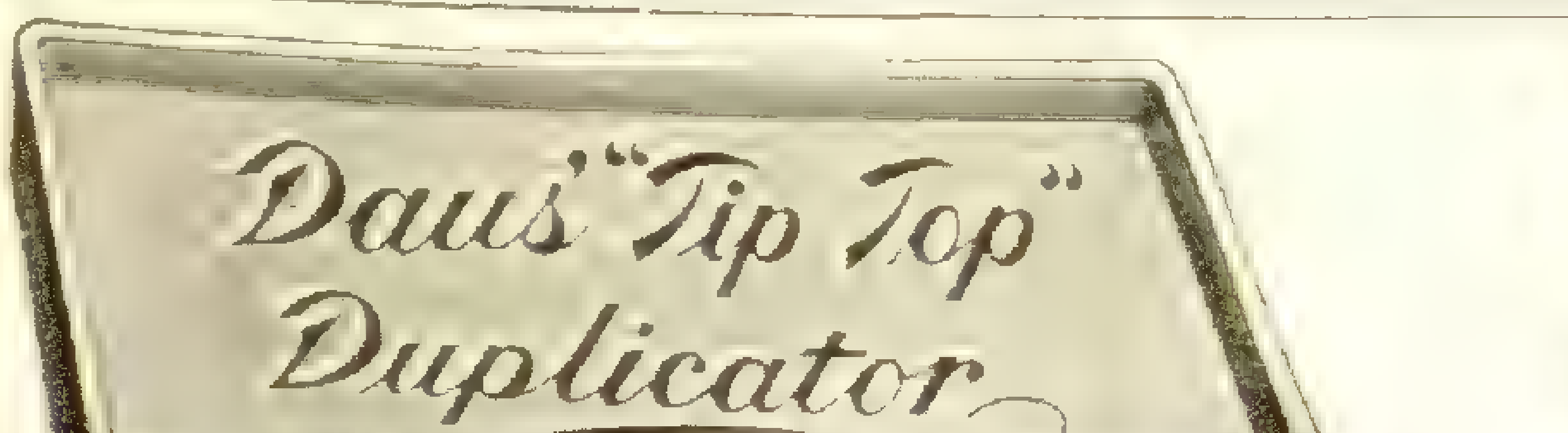

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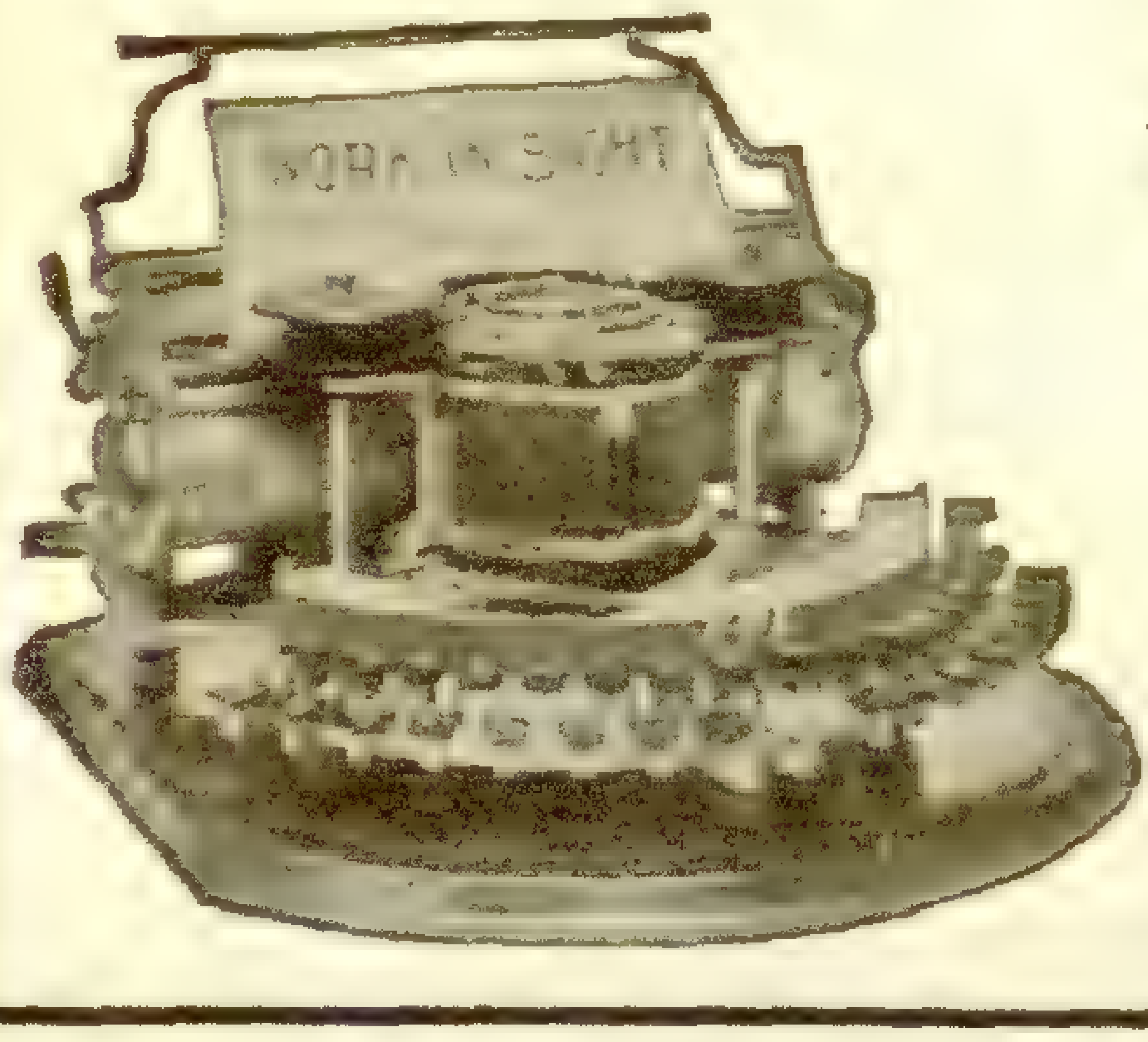

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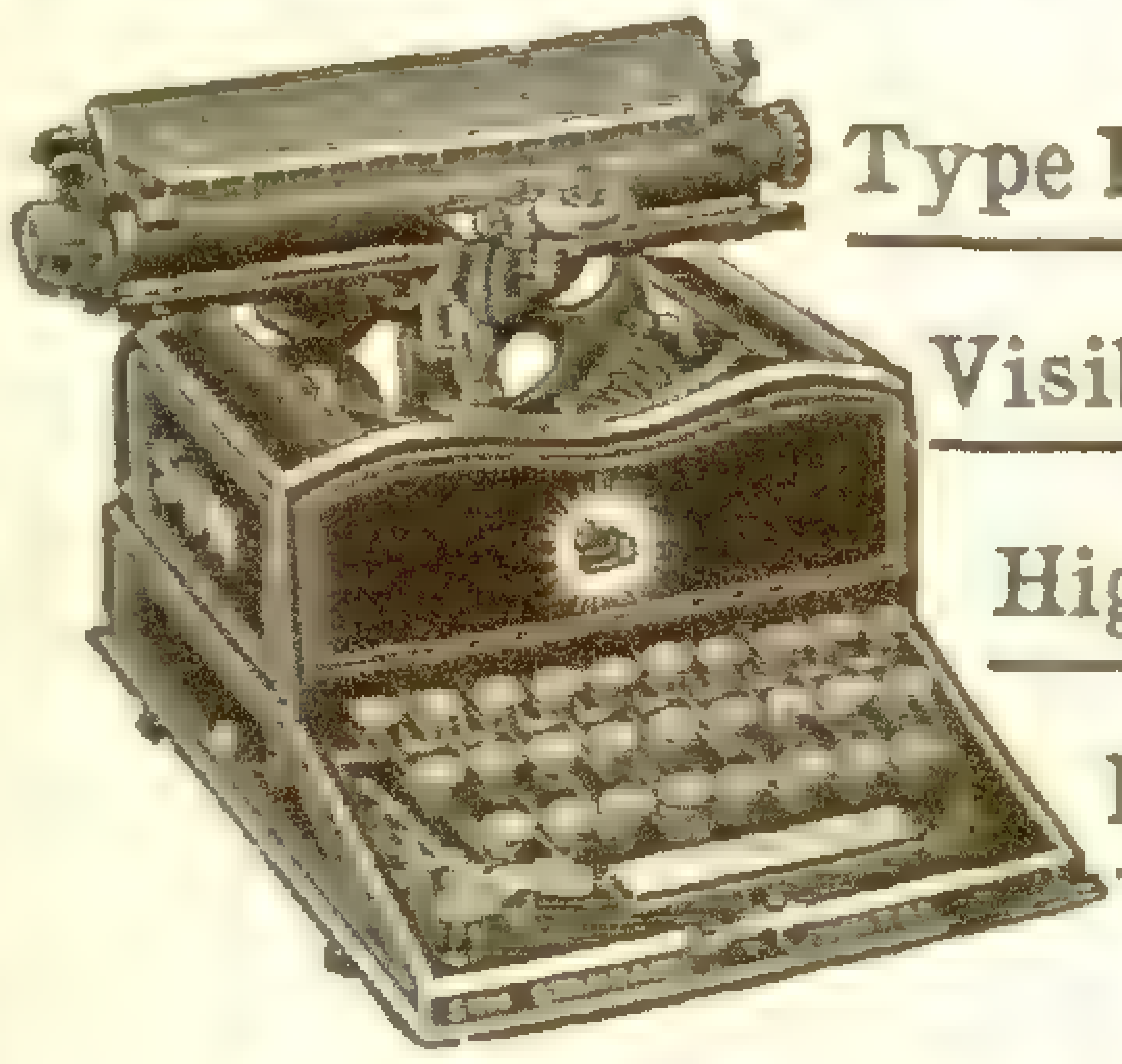

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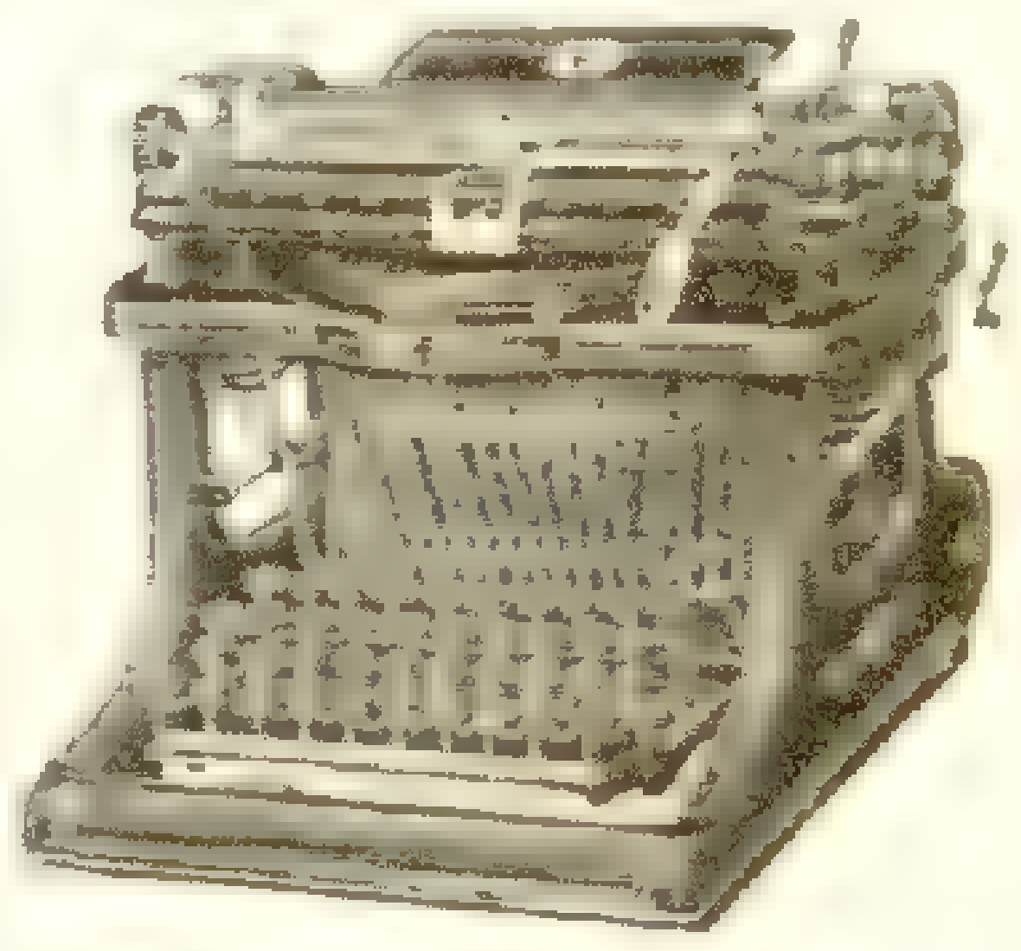

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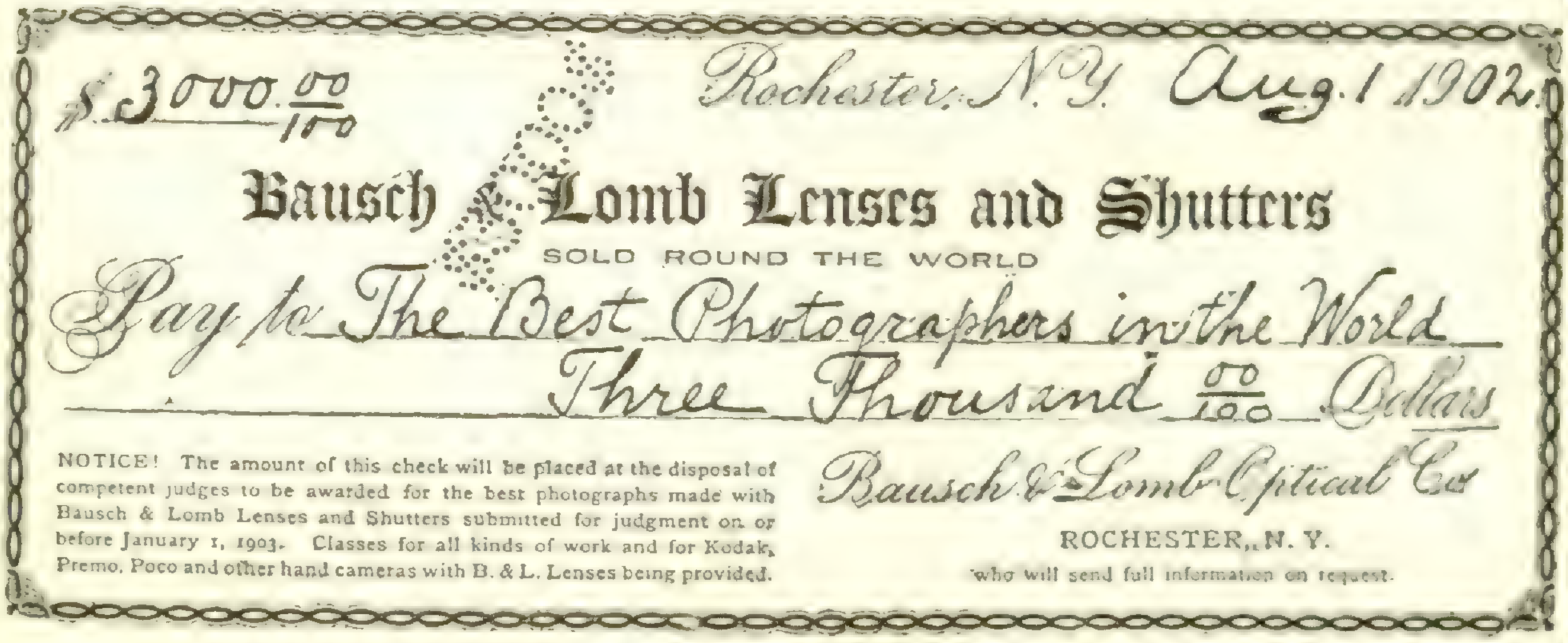

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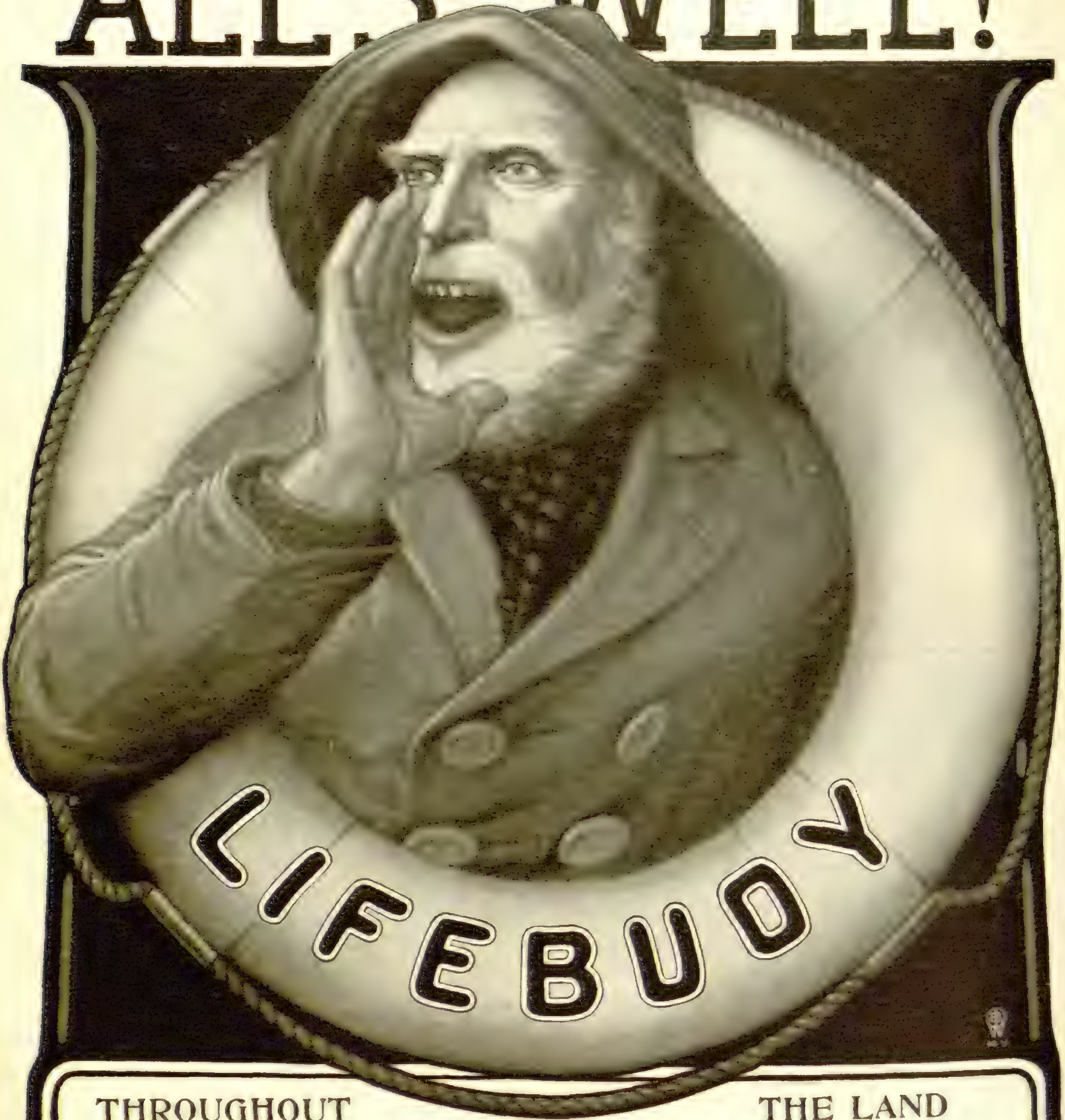

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The Best Policy it has for You.

WE WILL SUPPOSE THAT YOU ARE LOOKING FOR A POLICY SIMPLE IN FORM AND WITH MODERATE PAYMENTS. THEN THE PARTICIPATING WHOLE LIFE POLICY OF THE PRUDENTIAL IS WHAT YOU WANT. THIS POLICY STANDS AS A TYPE OF ALL THAT IS BEST AND MOST DESIRABLE IN LIFE INSURANCE. YOU PAY US AS PREMIUM ON YOUR POLICY A STATED AMOUNT EITHER ANNUALLY, SEMI-ANNUALLY OR QUARTERLY DURING YOUR LIFE. THE AMOUNT INSURED UNDER THE POLICY IS PAYABLE TO YOUR BENEFICIARY AT YOUR DEATH, IN ONE SUM, OR IT MAY BE MADE PAYABLE IN ANY NUMBER OF EQUAL ANNUAL INSTALMENTS, THUS PROVIDING AN ANNUAL INCOME TO YOUR BENEFICIARY FOR LIFE. ONE OF THE MANY LIBERAL FEATURES OF THIS POLICY IS THAT YOU SHARE IN THE PROFITS APPORTIONED BY THE COMPANY, KNOWN AS DIVIDENDS. THESE DIVIDENDS ARE INVESTED AND ALLOWED TO ACCUMULATE AT COMPOUND INTEREST FOR A PERIOD OF EITHER FIFTEEN OR TWENTY YEARS, AS YOU MAY CHOOSE WHEN TAKING OUT THE POLICY. AT THE END OF THE SELECTED PERIOD YOU MAY RECEIVE THESE ACCUMULATED DIVIDENDS IN CASH OR YOU MAY APPLY THEM TO REDUCE FUTURE PREMIUMS. THE WHOLE LIFE POLICY IS ISSUED ALSO WITH DIVIDENDS PAYABLE ANNUALLY OR AT INTERVALS OF FIVE YEARS. AFTER THE POLICY HAS BEEN IN FORCE THREE YEARS, YOU MAY BORROW MONEY FROM THE COMPANY ON THE SECURITY OF YOUR POLICY. THE AMOUNT THAT MAY BE BORROWED INCREASES WITH THE NUMBER OF PREMIUMS PAID. THE COST IS LOW, AND RATES WILL BE FURNISHED UPON REQUEST. SHOULD YOU DESIRE A POLICY WHERE EITHER YOU OR YOUR BENEFICIARY WILL DERIVE THE BENEFIT, WE WOULD RECOMMEND THE ENDOWMENT POLICY. UNDER THIS PLAN THE SUM INSURED IS PAYABLE TO YOU, IF LIVING AT THE END OF THE ENDOWMENT PERIOD, OR TO YOUR BENEFICIARY IF YOUR DEATH SHOULD OCCUR PREVIOUSLY. THE LENGTH OF THE ENDOWMENT PERIOD MAY BE TEN, FIFTEEN OR TWENTY YEARS, AS YOU MAY SELECT WHEN TAKING OUT THE POLICY. THE PREMIUMS ARE PAYABLE BY YOU EITHER ANNUALLY, SEMI-ANNUALLY OR QUARTERLY DURING THE LIFE OF THE POLICY, OR THEY MAY BE LIMITED TO A TERM OF YEARS, LESS THAN THE ENDOWMENT PERIOD IF YOU DESIRE. FOR EXAMPLE, THE PREMIUM ON A TWENTY-YEAR ENDOWMENT POLICY MAY BE PAID BY YOU DURING THE FIRST TEN YEARS IF YOU WISH. UNDER THE ENDOWMENT PLAN THE INSURED MAY NOT ONLY SECURE PROTECTION FOR HIS FAMILY, BUT HAVE A CONVENIENT AND PROFITABLE METHOD OF INVESTING HIS SAVINGS. THIS POLICY SHARES IN THE PROFITS APPORTIONED BY THE COMPANY IN THE SAME MANNER AS THE WHOLE LIFE POLICY. AFTER TWO YEARS' PREMIUMS HAVE BEEN PAID, YOU MAY BORROW MONEY FROM THE COMPANY ON THE SECURITY OF YOUR POLICY. THE POLICY HAS MANY OTHER LIBERAL PROVISIONS. SHOULD YOU DESIRE A POLICY THAT IS PAYABLE AT YOUR DEATH, BUT WISH TO LIMIT YOUR PREMIUM PAYMENTS TO A NUMBER OF YEARS, WE ISSUE WHAT IS KNOWN AS THE LIMITED-PAYMENT LIFE POLICY. THIS IS THE SAME AS THE WHOLE LIFE POLICY, EXCEPT THAT THE PAYMENTS ARE MADE BY YOU FOR TEN, FIFTEEN OR TWENTY YEARS ONLY, AS SELECTED WHEN TAKING OUT THE POLICY. IF YOU SURVIVE THE PREMIUM-PAYING PERIOD, THE POLICY IS CONTINUED IN FORCE ON THE BOOKS OF THE COMPANY, AND YOU MAY DRAW OUT YOUR DIVIDENDS, BUT NO FURTHER PREMIUM PAYMENTS ARE REQUIRED. THIS POLICY IS SUBJECT TO ALL THE PRIVILEGES AND BENEFITS OF THE WHOLE LIFE POLICY. AFTER THREE YEARS' PREMIUMS HAVE BEEN PAID YOU MAY BORROW MONEY FROM THE COMPANY ON THE SECURITY OF YOUR POLICY, AND THE AMOUNT YOU MAY BORROW INCREASES WITH THE NUMBER OF PREMIUMS PAID. SHOULD A POLICY FOR A SMALL AMOUNT BE DESIRED, ONE OF THE BEST FORMS IS THE INTERMEDIATE POLICY. IT IS ISSUED IN AMOUNTS OF $500, ON THE WHOLE LIFE, LIMITED-PAYMENT LIFE OR ENDOWMENT PLAN. THE INTERMEDIATE POLICY SHARES IN THE PROFITS APPORTIONED BY THE COMPANY, WHICH ARE CREDITED TO THE POLICY AFTER IT HAS BEEN IN FORCE FOR FIVE YEARS, AND EVERY YEAR THEREAFTER IT WILL, IF IN FORCE, BE CREDITED WITH AN ANNUAL DIVIDEND. THIS POLICY IS SUBJECT TO OTHER VALUABLE PRIVILEGES, WHICH WILL BE EXPLAINED UPON REQUEST. THE INDUSTRIAL POLICY IS VERY POPULAR, AND IS ISSUED IN AMOUNTS FROM $15 TO $500 TO PERSONS BETWEEN AGES ONE AND SEVENTY. THE PREMIUM PAYMENTS ARE MADE BY THE POLICY-HOLDER IN SMALL WEEKLY SUMS, SUCH AS TEN, FIFTEEN OR TWENTY CENTS A WEEK, AND UPWARDS, FOR WHICH OUR AGENT CALLS. THIS POLICY PROVIDES FOR PAYMENT OF THE CLAIM BY THE COMPANY IMMEDIATELY ON ACCEPTANCE OF SATISFACTORY PROOF OF DEATH, AS DO ALL THE POLICIES ISSUED BY THE PRUDENTIAL. AFTER IT HAS BEEN IN FORCE FIVE YEARS, THE INDUSTRIAL POLICY IS CREDITED WITH DIVIDENDS, WHICH ARE ADDED TO THE POLICY, SO THAT IT BECOMES MORE AND MORE VALUABLE AS IT GROWS OLDER. AT THE END OF FIFTEEN YEARS, A CASH DIVIDEND IS PAID BY THE COMPANY. THIS POLICY PROVIDES FULL PROTECTION TO PERSONS WHO WISH A SMALL AMOUNT OF LIFE INSURANCE AT MODERATE COST.

A POLICY THE FACE VALUE OF WHICH IS INCREASED EVERY YEAR BY A GUARANTEED ADDITION OF FIVE PER CENT. OF THE INITIAL AMOUNT IS FOUND IN THE POPULAR GUARANTEED FIVE PER CENT. TWENTY YEAR ENDOWMENT BOND. SHOULD YOU SURVIVE THE TWENTY YEARS, THE INITIAL SUM, TOGETHER WITH ALL THE ACCUMULATED GUARANTEED ADDITIONS, BECOMES PAYABLE TO YOU IN CASH. IN OTHER WORDS, WE WILL SUPPOSE YOU TAKE OUT A BOND FOR $1,000. IF YOU WERE TO DIE AT ANY TIME WITHIN THE TWENTY YEARS, YOUR BENEFICIARY WOULD GET THIS $1,000, PLUS $50 FOR EVERY CONTRACT YEAR UPON WHICH YOUR POLICY HAD ENTERED. AT THE END OF THE TWENTY YEARS, IF THE BOND WERE IN FORCE, YOU WOULD RECEIVE JUST TWICE THE INITIAL AMOUNT OF THE BOND, OR $2,000. SHOULD YOU PREFER TO HAVE THIS AMOUNT PAID TO YOU IN INSTALMENTS, YOU MAY HAVE AN ANNUITY. THIS WOULD PRACTICALLY PROVIDE A PENSION FOR THE REST OF YOUR LIFE. SHOULD YOU DIE BEFORE THE END OF THE TWENTY YEARS, IF THE BOND IS IN FORCE YOUR BENEFICIARY MAY, INSTEAD OF RECEIVING THE CASH, LEAVE IT WITH THE COMPANY IN TRUST, BEARING INTEREST AT THE RATE OF THREE PER CENT. PER ANNUM, IF YOU SO DESIRE. YOUR BENEFICIARY MAY RECEIVE THE AMOUNT IN EQUAL ANNUAL INSTALMENTS, THEREBY PROVIDING AN INCOME DURING HIS OR HER ENTIRE LIFE. THE FIVE PER CENT. GOLD BOND POLICY AT ITS MATURITY, EITHER AS AN ENDOWMENT OR A DEATH CLAIM, OFFERS THE HOLDER HIS CHOICE OF TWO VALUABLE OPTIONS: FIRST, TO RECEIVE COUPON BONDS IN SUMS OF $1,000 EACH, MATURING IN TWENTY YEARS, GUARANTEEING FIVE PER CENT. INTEREST PER ANNUM, PAYABLE SEMI-ANNUALLY IN ADVANCE IN GOLD. SECOND, IN PLACE OF THE BONDS, TO RECEIVE IN GOLD COIN THE SUM OF $1,283 FOR EACH $1,000 OF THE FACE VALUE OF THE POLICY. THE RESULT IS A SURE INVESTMENT, A GUARANTEED INCOME AT A HIGH RATE OF INTEREST, AND NO EXPENSE OR WORRY OVER THE MANAGEMENT OF THIS PART OF ONE'S ESTATE. MOREOVER, THE PRUDENTIAL SELLS THIS FORM OF INSURANCE UPON THE BASIS OF ABSOLUTE GUARANTEES, NO ESTIMATES, NOTHING PROVISIONAL, AND AT A PRICE SO LOW AS TO MAKE IT FOR THE MAJORITY OF PEOPLE ONE OF THE MOST ADVANTAGEOUS POLICIES IN THE LIFE INSURANCE MARKET. THESE POLICIES ARE ALSO ISSUED UPON THE PARTICIPATING PLAN.

THE PRUDENTIAL HAS THE STRENGTH OF GIBRALTAR

THE FOLLOWING ARE SOME OF THE LIBERAL FEATURES CONTAINED IN THE ORDINARY POLICIES NOW ISSUED BY THE PRUDENTIAL: AFTER ONE YEAR FROM THEIR DATE, IF THE PREMIUMS BE PAID AS STIPULATED, THE POLICIES BECOME INCONTESTABLE. DEATH FROM SUICIDE WILL NOT INVALIDATE THE POLICY AFTER IT HAS BEEN ONE YEAR IN FORCE. AFTER A POLICY HAS ONCE BEEN ISSUED AND PAID FOR THERE ARE NO RESTRICTIONS AS TO RESIDENCE, TRAVEL OR OCCUPATION, NOR WILL A PERMIT OR EXTRA PREMIUM BE REQUIRED IN CASE OF MILITARY SERVICE, WHETHER IN TIME OF PEACE OR WAR. THE MANNER OF PAYMENT OF PREMIUMS MAY BE CHANGED ON ANY SUBSEQUENT ANNIVERSARY DATE OF THE POLICY. A GRACE OF ONE MONTH, WITHOUT INTEREST, WILL BE ALLOWED IN THE PAYMENT OF ANY PREMIUM EXCEPT THE FIRST. DURING THE PERIOD OF GRACE THE POLICY REMAINS IN FULL FORCE. THE CASH LOAN PRIVILEGE CONTAINED IN ORDINARY POLICIES VIRTUALLY MAKES EVERY POLICY A NEGOTIABLE BOND. THE INSURED MAY AT ANY TIME WHILE THE POLICY IS IN FORCE NAME A NEW BENEFICIARY. THE AMOUNT INSURED UNDER THE POLICY IS PAYABLE IN ONE SUM, BUT MAY BE MADE PAYABLE IN ANY NUMBER OF EQUAL ANNUAL INSTALMENTS, FROM TWO TO TWENTY-FIVE, OR IT MAY BE MADE PAYABLE TO THE BENEFICIARY IN CONTINUOUS INSTALMENTS, THAT IS, IT MAY BE MADE PAYABLE IN EQUAL ANNUAL INSTALMENTS TO CONTINUE AT LEAST TWENTY YEARS, AND AS LONG THEREAFTER AS THE BENEFICIARY SHALL LIVE. EACH INSTALMENT, EXCEPT THE FIRST, WILL BE INCREASED BY SUCH ANNUAL DIVIDEND AS MAY BE APPORTIONED BY THE COMPANY AT THE TIME THE POLICY BECOMES PAYABLE AS A CLAIM. THE AMOUNT INSURED, OR ANY PORTION THEREOF NOT LESS THAN $1,000, MAY BE LEFT DURING THE LIFETIME OF THE BENEFICIARY IN TRUST WITH THE COMPANY, WHICH WILL PAY THEREON, AS LONG AS THE SAID AMOUNT REMAINS IN TRUST, INTEREST AT THE RATE OF THREE PER CENT. PER ANNUM, TOGETHER WITH SUCH ANNUAL DIVIDEND AS MAY BE APPORTIONED BY THE COMPANY. THE SAID TRUST FUND SHALL BE PAID AT THE DEATH OF THE BENEFICIARY TO THE EXECUTORS, ADMINISTRATORS OR ASSIGNS OF THE BENEFICIARY, BUT MAY BE WITHDRAWN AT ANY TIME, WITH ACCRUED INTEREST. IN THE CASE OF POLICIES MATURING AS ENDOWMENTS, THE INSTALMENT PRIVILEGE OR TRUST FUND PRIVILEGE MAY BE EXERCISED BY THE INSURED FOR HIS OWN BENEFIT. THE FOLLOWING VALUABLE PRIVILEGES ARE EXTENDED TO THOSE WHO MAY DISCONTINUE THEIR PREMIUMS: IF THE POLICY LAPSE FOR NON-PAYMENT OF PREMIUM AT ANY TIME AFTER HAVING BEEN IN FORCE ONE FULL YEAR, THE COMPANY WILL GRANT EXTENDED INSURANCE. THAT IS, IN THE CASE OF A POLICY LAPSED AT THE END OF ONE YEAR, OR ANY TIME THEREAFTER, THE POLICY-HOLDER WILL STILL BE INSURED FOR A FURTHER PERIOD, GIVEN IN THE POLICY, AND IN CERTAIN CASES UNDER ENDOWMENT POLICIES, THE POLICY-HOLDER IS INSURED TILL THE END OF THE ENDOWMENT PERIOD, AND IN ADDITION RECEIVES AT THAT TIME, A CERTAIN AMOUNT IN CASH AS A PURE ENDOWMENT. THUS THE POLICY-HOLDER IS COMPLETELY AND AUTOMATICALLY PROTECTED IN EVERY CASE. IF DESIRED, INSTEAD OF EXTENDED INSURANCE FOR THE FULL AMOUNT OF POLICY, A PAID-UP POLICY FOR A SMALLER AMOUNT MAY BE HAD. SUCH A POLICY MAY BE OBTAINED AT ANY TIME AFTER THE ORIGINAL POLICY HAS BEEN THREE YEARS IN FORCE (TWO YEARS IN CASE OF ENDOWMENTS) BY MAKING PROPER APPLICATION AND SURRENDERING THE ORIGINAL POLICY TO THE COMPANY. THEN, TOO, THE INSURED IS GIVEN AN OPPORTUNITY, PROVIDED ALL DUE PREMIUMS HAVE BEEN PAID, OF REALIZING, IF DESIRED, THE CASH VALUE OF THE POLICY ITSELF, THAT IS, OF SURRENDERING THE POLICY TO THE COMPANY IN RETURN FOR A LIBERAL CASH VALUE, THE AMOUNT OF WHICH INCREASES WITH EACH PREMIUM PAID AND IS PLAINLY STATED FOR EACH YEAR IN THE POLICY. THE POLICY ALSO CONTAINS LIBERAL PROVISION FOR REINSTATEMENT IN CASE OF LAPSE. APPLICATIONS FOR LIFE INSURANCE MAY BE MADE TO ANY OF THE COMPANY'S AGENTS, AND A SPECIMEN POLICY WILL BE SENT YOU AT ANY TIME UPON REQUEST. WRITE FOR FURTHER PARTICULARS TO THE PRUDENTIAL INSURANCE COMPANY OF AMERICA, HOME OFFICE, NEWARK, N. J.

THE PRUDENTIAL

Insurance Company of America

JOHN F. DRYDEN,
President.

Write for Information. Dept. 25

HOME OFFICE,
Newark, N. J.

VOLUME XXXV NUMBER 6

BOTANICAL GAZETTE

JUNE, 1903

CRATAEGUS IN NORTHEASTERN ILLINOIS.

C. S. SARGENT.

THIS paper is based chiefly on the large collections and on the notes made in the neighborhood of Chicago, by Mr. E. J. Hill, of that city, during the last four years. Mr. William C. Egan, of Lake Forest, Mr. Robert Bebb, of Chicago, Mr. H. C. Skeels, of Joliet, and Mr. B. T. Gault, of Glen Ellyn, have also made important collections of Crataegus in this region. The field, however, is by no means exhausted, and there are indications in all these collections of forms which cannot now be described for want of fuller information.

CRUS-GALLI.

Stamens 10.

Anthers rose color.

CRATAEGUS PEORIENSIS Sargent, BOT. GAZ. **31**: 5. 1901; Silva N. Am. **13**: 45. *pl. 640.*

Joliet, *E. J. Hill,* June and October 1901, May and September 1902; *H. C. Skeels,* May 1902.

Anthers pale yellow.

Crataegus Arduennae, n.sp.—Glabrous. Leaves obovate, acute, acuminate or rounded at the apex, gradually narrowed from near the middle to the entire cuneate base, finely crenately serrate above, with glandular teeth; deeply tinged with red as they unfold and nearly fully grown when the flowers open; at maturity subcoriaceous, dark green and very lustrous on the upper surface, pale on the lower surface, 4.5–6^{cm} long, 1.5–3^{cm} wide, with slender yellow midribs and obscure primary veins mostly within the parenchyma; petioles stout, grooved, winged below the middle by the decurrent base of the leaf-blades, occasionally sparingly glandular, 6–14$^{\mathrm{mm}}$ in length; stipules linear, dark red, minute, caducous; on vigorous shoots leaves usually elliptical, short-pointed, very coarsely serrate, usually laterally lobed, 6–7$^{\mathrm{cm}}$ long, 4–5$^{\mathrm{cm}}$ wide, with stout midribs and prominent slender primary veins, their stipules foliaceous, lunate, coarsely glandular-serrate, stalked, sometimes 1.5$^{\mathrm{cm}}$ in length. Flowers 1.2–1 5$^{\mathrm{cm}}$ in diameter on long slender pedicels, in broad thin-branched many-flowered compound corymbs; bracts and bractlets linear, minute, caducous; calyx-tube narrowly obconic, the lobes abruptly narrowed from the base, linear, acuminate, tipped with small dark red glands, entire or rarely slightly and irregularly serrate, reflexed after anthesis; stamens 5–12, usually 10; anthers small, pale yellow; styles 1 or 2. Fruit on slender pedicels, in drooping many-fruited clusters, oblong, dull dark crimson marked by large pale dots, about 1$^{\mathrm{cm}}$ long, 8–10$^{\mathrm{mm}}$ wide; calyx small, sessile, with a narrow shallow cavity and reflexed and appressed lobes; flesh thin, yellow, dry and mealy; nutlet 1, gradually narrowed from the middle to the obtuse ends, grooved and irregularly ridged on the dorsal face; or 2 and then broad, rounded at the ends, prominently ridged on the back with a high wide rounded ridge, about 8$^{\mathrm{mm}}$ in length.

A shrub 3–4$^{\mathrm{m}}$ tall with numerous erect stems and branches covered with smooth light gray bark, and slender slightly zigzag branchlets, light orange-green and marked by small pale lenticels when they first appear, dark purple and lustrous at the end of their first season, dark grayish-brown the following year, and armed with many slender straight or slightly curved dark purple shining spines 4.5–8$^{\mathrm{cm}}$ long. Flowers during the last week of May or early in June. Fruit ripens the middle of September.

Glen Ellyn, Du Page county, *B. F. Gault*, June 1901; rich clay loam in ravines near water or in depressions near the top of a clay hill, "Forest of Arden," Joliet, *E. J. Hill*, May and September 1902, *H. S. Skeels*, May 1902.

At Joliet Mr. H. N. Higginbotham has planned and planted a garden of three hundred acres. It is called the Forest of Arden, and here are to be brought together the trees and shrubs and other plants of the United States which can support the climate of Illinois. I am glad to adopt Mr. Hill's suggestion and associate with this thorn the name of the garden where it grows spontaneously.

PRUINOSAE.

Stamens 20.

Anthers rose color.

Crataegus pruinosa K. Koch; Sargent, Silva N. Am. **13**:68. *pl. 648.*

Barrington, May and September 1901, Highland Park, May and October 1902, Bremen, October 1901, May 1902, *E. J. Hill;* Lake Forest, September 1901, *W. C. Egan;* Milton, DuPage county, May and September 1902, *B. T. Gault.*

Anthers pale yellow.

Crataegus conjuncta Sargent, Rhodora **5**: 57. 1903.

Mokena, May and October 1897, September 1898, May, September and October 1900, Highland Park, May and October 1902, Deerfield, May and September 1902, Bremen, May 1902, *E. J. Hill;* Highland Park, *W. C. Egan,* May and September 1901.

Stamens 10.

Anthers rose color.

Crataegus dissona Sargent, Rhodora **5**: 60. 1903.

Clay banks of Lake Zurich, and adjacent oak woods, *E. J. Hill,* September 9, 1895, May and September 1899, May and October 1901, *C. S. Sargent,* September 1899; gravelly banks of Salt Creek, La Grange, *E. J. Hill,* June and September 1902.

PUNCTATAE.

Crataegus punctata Jacquin.

Common.

MOLLES.

Stamens 20.

Anthers pale yellow.

Crataegus mollis Scheele, Sargent, Silva N. Am. **13**: 83. *pl. 659.*

Common.

Crataegus sera Sargent, Bot. Gaz. **33**: 115. 1902; Silva N. Am. **13**: 87. *pl. 661.*

Bottoms of the Desplaines and Calumet rivers, and Barrington.

Anthers rose color.

Crataegus corusca Sargent, Bot. Gaz. **33**: 117. 1902; Silva N. Am. **13**: 99. *pl. 667.*

Shores of Lake Zurich. Rare.

LOBULATAE.

Anthers pink or rose color.

Stamens 5–10.

Crataegus elongata, n. sp.—Leaves oblong-ovate, acuminate, rounded or concave-cuneate at the broad often unsymmetrical entire glandular base, finely doubly serrate above, with straight or incurved teeth tipped with small red glands, and very slightly divided into three or four pairs of acuminate lateral lobes; thickly coated above as they unfold with shining white hairs and villose below; more than half grown when the flowers open and then membranaceous, light yellow-green and still villose; at maturity thin but firm in texture, dark yellow-green, smooth and glabrous on the upper surface, pale yellow-green on the lower surface, 6–7 ^{cm} long, 4.5–5.5 ^{cm} wide, with stout midribs deeply impressed above and occasionally furnished with a few scattered hairs along their rose-colored base, and 5 or 6 pairs of slender primary veins extending to the points of the lobes; petioles very slender, wing-margined at the apex, slightly grooved, villose and sparingly glandular early in the season, 2.5-3 ^{cm} in length. Flowers on slender pedicels, thickly coated like the narrowly obconic tube of the calyx with long pale hairs, in very long thin-branched few-flowered villose corymbs; calyx lobes narrow, acuminate, glandular-serrate, glabrous on the outer, villose on the inner face, reflexed after anthesis; stamens five; anthers pale pink; styles 3 or 4. Fruit on elongated pubescent pedicels, in gracefully drooping few-fruited clusters, oblong-obovate, crimson, lustrous, marked by numerous small pale dots, about 1.5 ^{cm} long and 8 ^{mm} wide; calyx persistent, with a broad deep cavity and spreading and reflexed much enlarged lobes, their tips usually deciduous from the ripe fruit; flesh thick, dry and mealy; nutlets three or four, thin, gradually narrowed and acute at the apex, full and rounded at the base, ridged on the back, usually with a broad grooved ridge, 9–10 ^{mm} long.

A small tree with slender straight branchlets, dark orange-green marked by oblong pale lenticels and villose when they first appear, bright red-brown, glabrous or puberulous at the end of their first season, and dull dark gray-brown the following year, and unarmed or armed with stout, slightly curved dark red-brown shining spines about 4.5^{cm} long. Flowers about the 20th of May. Fruit ripens the middle of September.

Deerfield, *William C. Egan*, May 21, 1902, *E. J. Hill*, September 10, 1902.

Well distinguished from the other described species of this group by the few-flowered corymbs, the long narrow small fruits, and the small leaves.

Crataegus sertata, n. sp.—Leaves oblong-ovate, acuminate at the apex, rounded, truncate, subcordate or rarely cuneate at the broad base, finely and often doubly serrate, with straight gland-tipped teeth, and deeply divided into five or six pairs of wide acuminate lobes; thickly coated on the upper surface when they unfold with short pale hairs and villose below along the midribs and veins, and about half-grown and villose when the flowers open; at maturity membranaceous, dark yellow-green and scabrate above, pale yellow-green and glabrous below, 6–7^{cm} long, 4.5–6.5^{cm} wide, with thin yellow midribs and slender primary veins arching obliquely to the points of the lobes; petioles slender, slightly grooved, villose early in the season, ultimately glabrous, sparingly glandular, 1.5–3^{cm} in length; stipules linear to lanceolate, finely glandular-serrate, caducous. Flowers 2–2.5^{cm} in diameter, in broad 10–15-flowered compound densely villose corymbs; bracts and bractlets linear to linear-obovate, glandular, large and conspicuous, caducous; calyx tube broadly obconic, glabrous above, villose below like the slender pedicel, the lobes abruptly narrowed from the base, broad, acuminate, tipped with small red glands, coarsely glandular-serrate, glabrate on the outer, pubescent on the inner surface, reflexed after anthesis; stamens 5–10, usually 5; anthers pale rose color; styles 3–5, surrounded at the base by tufts of pale hairs. Fruit on slender villose-pubescent pedicels, in drooping many-fruited clusters, subglobose to slightly obovate, full and rounded at the ends, bright red and lustrous, becoming darker or crimson when fully ripe, marked by occasional large pale dots, 1.1–1.5^{cm} long, from 1–1.4^{cm} wide; calyx sessile, with a broad deep cavity and enlarged mostly erect and incurved serrate lobes; flesh thin, yellow, aromatic, pleasantly acid; nutlets 3–5, usually 4, thin, narrowed and acute at the ends, slightly ridged on the back, with a wide or narrow ridge, 8^{mm} in length.

A tree $6–7^{\mathrm{m}}$ in height with a trunk occasionally $2–2.5^{\mathrm{m}}$ long and $1.5–1.8^{\mathrm{dm}}$ in diameter, covered with close dark gray bark $6–7^{\mathrm{mm}}$ thick, separating into long narrow thin plate-like scales, stout spreading branches forming a handsome open head, and slender nearly straight branchlets thickly coated when they first appear with matted pale hairs, light red-brown and lustrous at the end of their first season and dark gray-brown the following year, and unarmed or armed with stout nearly straight or curved spines from $2.5–6^{\mathrm{cm}}$ long. Flowers from the 5th to the 15th of May. Fruit ripens about the middle of September and soon falls.

Open woods and pastures in rich moist soil, Barrington, May and September 1899, Mokena, September 1899, May 1900, May and September 1901, Glendon Park, May and September 1901, Lake Zurich, May and September 1901, *E. J. Hill.*

Stamens usually 20, rarely 10.

Crataegus assurgens, n. sp.—Leaves broadly ovate, acuminate, rounded or rarely cuneate at the wide entire base, sharply doubly serrate above, with straight gland-tipped teeth and slightly divided into three or four pairs of small acuminate lobes; about one-third grown when the flowers open and then roughened above by short white hairs and glabrous or sparingly villose below along the midribs and veins with persistent hairs; at maturity membranaceous, dull dark green and scabrate on the upper surface, light yellow-green on the lower surface, $7–9^{\mathrm{cm}}$ long, $6–7^{\mathrm{cm}}$ wide, with slender yellow midribs and thin veins arching obliquely to the points of the lobes; petioles slender, slightly grooved, villose early in the season, becoming pubescent, $2.5–4^{\mathrm{cm}}$ in length; stipules linear to linear-obovate, acuminate, glandular, caducous; on vigorous shoots leaves often deeply lobed, very coarsely serrate, sometimes 10^{cm} long and wide, with long stout glandular petioles and foliaceous lunate acuminate coarsely glandular-serrate persistent stipules. Flowers $1.8–2.2^{\mathrm{cm}}$ in diameter on short villose pedicels, in rather compact 8–15-flowered thin-branched hairy compound corymbs; bracts and bractlets oblong, acuminate, often somewhat falcate, glandular, turning brown in fading, mostly deciduous with the opening of the flowers; calyx tube narrowly obconic, sparingly villose, the lobes long, narrow acuminate, tipped with minute red glands, finely glandular-serrate, glabrous on the outer, pubescent on the inner face, reflexed after anthesis; stamens 10–20, usually 10; anthers pinkish purple; styles 4 or 5, surrounded at the base by tufts of pale hairs. Fruit on short stout glabrous pedicels, in drooping, few-fruited clusters, oblong to slightly obovate, dull red or crimson, 1.2–1.8^{cm} long, 1–1.5^{cm} wide; calyx sessile with a broad shallow cavity and spreading closely appressed serrate usually persistent lobes; flesh thin, pale yellow or nearly white, acidulous; nutlets 4 or 5, broad, acute at the ends, prominently ridged on the back, with a high narrow ridge, or often grooved, 6–7^{mm} in length.

A broad much-branched shrub 2–4^{m} tall, or more often and in better soil a tree with an oblong head rising sometimes to the height of 8^{m} and forming a trunk 2–3^{m} long and 0.5–1.5^{dm} in diameter, covered with close dark gray bark; branchlets slender, light orange-yellow, marked by pale lenticels and furnished with long scattered caducous white hairs when they first appear, bright red-brown and lustrous during their first season, and dull dark gray-brown the following year, and armed with many stout usually slightly curved bright red-brown shining spines 2.5–4^{cm} long. Flowers the middle of May. Fruit ripens from the 15th to the 20th of September and usually falls about the 1st of October or earlier, sometimes remaining on the branches until the middle of that month.

River banks and woods in rich soil, Leyden township, May and September 1900, 1902, La Grange, June and September 1902, Thatcher's Park, May, September and October 1901, May 1902, *E. J. Hill.*

Crataegus magniflora, n. sp.—Leaves oblong-ovate, acute or acuminate, rounded or rarely cuneate at the broad entire base, coarsely doubly serrate above, with straight glandular teeth and slightly divided into numerous narrow acuminate lateral lobes; about half-grown when the flowers open and then membranaceous, light yellow-green and roughened by short white hairs and pale and glabrous below; at maturity thin but firm in texture, dark yellow-green and scabrate on the upper surface, paler on the lower surface, 6–7^{cm} long, 4–6^{cm} wide, with slender yellow midribs and thin primary veins extending obliquely to the points of the lobes; petioles slender, nearly terete, slightly grooved, puberulous early in the season, soon glabrous, 1.5–3.5^{cm} in length; stipules linear, acuminate, minute, bright red, caducous. Flowers 2.5–3^{cm} in diameter on long slender glabrous pedicels, in compact 7–10-flowered thin-branched glabrous corymbs; bracts and bractlets linear to linear-oblong, acuminate, finely glandular-serrate, turning red before falling, mostly persistent until after the flowers open; calyx tube broadly obconic, the lobes gradually narrowed from the base, wide, acuminate, coarsely glandular-serrate, glabrous on the outer, slightly villose on the inner surface, reflexed after anthesis; stamens 20; anthers pink; styles 3–5, surrounded at the base by a narrow ring of pale tomentum. Fruit on slender rigid erect pedicels in few-fruited clusters, narrow, obovate at first when fully grown, becoming finally short-obovate to globose, full and rounded at the ends, dark crimson marked by few large pale dots, about 1.6 ^{cm} long and 1.4 ^{cm} wide; calyx sessile, with a broad shallow cavity and slightly enlarged erect and incurved lobes often deciduous from the ripe fruit; flesh thin, yellow, dry and mealy; nutlets three to five, usually four, thin, high and often gibbous in the middle, abruptly narrowed to the acute ends, usually prominently ridged, with a broad deeply grooved ridge, or rounded and slightly grooved on the back, about 8 ^{mm} long.

A bushy tree 6–7 ^{m} in height with slender nearly straight branchlets, dark orange-green and glabrous when they first appear, soon becoming dull orange or reddish brown and marked by many small pale lenticels, and darker grayish brown the following year, and slightly armed with stout straight or slightly curved dark red-brown spines about 3.5 ^{cm} in length. Flowers the middle of May. Fruit ripens from the 10th to the middle of September.

Borders of woods, in gravelly soil, Glendon Park, *E. J. Hill*, May, June, and September 1901.

Crataegus Hillii, n. sp.—Leaves oblong-ovate, acuminate, rounded or rarely cuneate at the broad entire base, coarsely doubly serrate above, with straight glandular teeth, and slightly divided into numerous short acuminate lateral lobes; when they unfold coated above with short lustrous white hairs and densely tomentose below particularly on the midribs and veins; about one-quarter grown when the flowers open and then roughened above by short hairs and still villose below; at maturity thin but firm in texture, light yellow-green and scabrate on the upper surface, pale yellow-green on the lower surface, 6–8 ^{cm} long, 5–6 ^{cm} wide, with slender midribs often slightly hairy near the base, and 4 or 5 pairs of thin primary veins extending obliquely to the points of the lobes; petioles slender, slightly grooved, densely villose early in the season, 2.5–4^{cm} in length; stipules oblong, often falcate, coarsely glandular-serrate, villose, 7–8^{mm} long, usually persistent until the flowers have opened; on vigorous shoots leaves often truncate or slightly cordate at the base, deeply lobed with broad nearly triangular lobes, frequently 9–10^{cm} long and broad with stout rose-colored glandular petioles and villose lunate glandular-serrate stipules. Flowers 1.8–2^{cm} in diameter on slender densely villose pedicels, in broad many-flowered thin-branched hairy compound corymbs; bracts and bractlets, large, linear to oblong, acuminate, glandular with dark red glands, occasionally persistent until midsummer; calyx tube narrowly obconic, thickly covered with long spreading white hairs, the lobes abruptly narrowed at the base, broad, acuminate, coarsely glandular-serrate, glabrous on the outer, villose on the inner face; stamens 20; anthers pink; styles 4 or 5, surrounded at the base by a narrow ring of pale tomentum. Fruit drooping on slender puberulous pedicels, in few-fruited clusters, obovate, full and rounded at the apex, gradually narrowed to the rounded base, crimson, lustrous, marked by small dark dots, 1.4–1.6^{cm} long, 1–1.2^{cm} wide; calyx sessile, with a broad shallow cavity and slightly enlarged closely appressed coarsely serrate lobes often deciduous from the ripe fruit; flesh yellow, thin, acidulous, juicy; nutlets 4 or 5, thin, acute at the ends, irregularly ridged and sometimes grooved on the back, about 9^{mm} in length.

A tree 8 or 9^{m} in height with a straight trunk sometimes 2^{m} long and 3^{dm} in diameter, covered with close, light gray bark tinged with red and divided by shallow fissures into small plates, stout ascending branches forming an open irregular often round-topped head, and slender nearly straight branchlets, densely villose when they first appear, dark orange color tinged with red, marked by many oblong pale lenticels, and sparingly villose when the flowers open, bright red-brown and lustrous at the end of their first season, becoming dark dull reddish-brown the following year, and sparingly armed with slender, nearly straight red-brown shining spines 3.5–5^{cm} long. Flowers the middle of May. Fruit ripens from the middle to the end of September.

Open woods or near the borders of streams in moist rich soil, Thatcher's Park, September, 1899, May, August and September 1900, May and September 1901, Glendon Park, October 1900, woods by Desplaines river, River

Forest, May, June and September 1901, *E. J. Hill*; Thatcher's Park, *C. S. Sargent*, September 1900.

This species resembles *Crataegus pedicellata* Sargent, of the valley of the Genesee river in New York, but differs from it in its much more villose corymbs, stouter pedicels, more numerous stamens, and smaller obovate fruits with small closely appressed not erect and incurved calyx-lobes. This is one of the largest and handsomest thorn trees of the region and may properly help to perpetuate the name of its discoverer, Ellsworth Jerome Hill, who with unfailing energy and through many seasons has studied Crataegus in the neighborhood of Chicago.

TENUIFOLIAE.

Anthers pink or rose color.

Stamens 5–10, usually 5.

Crataegus apiomorpha, n. sp.—Leaves oblong-ovate, acuminate, rounded or rarely cuneate at the entire often unsymmetrical base, finely doubly serrate above, with slender glandular teeth and slightly divided above the middle into 4 or 5 pairs of nearly triangular acute lobes; about half-grown when the flowers open and then membranaceous, light yellow-green and tinged with red or bronze color, covered above with short white hairs and pale and glabrous below; at maturity thick and firm in texture, dark blue-green and smooth and lustrous or sometimes dull and scabrate on the upper surface, pale blue-green on the lower surface, 4–6 or on leading shoots to 8^{cm} long, $3–4^{cm}$ wide, with stout midribs deeply impressed on the upper side and primary veins arching obliquely to the points of the lobes; petioles slender, slightly winged at the apex, grooved, often sparingly glandular, $1.5–2.5^{cm}$ in length; stipules linear, acuminate, glandular, caducous. Flowers $1.2–1.8^{cm}$ in diameter on short villose or glabrous pedicels, in compact, many-flowered usually hairy thin branched compound corymbs; bracts and bractlets linear to oblong-obovate and rounded at the apex, finely glandular-serrate, with stipitate dark red or purple glands, large, turning red before falling, mostly persistent until after the flowers open; calyx tube narrowly obconic, glabrous, the lobes abruptly narrowed at the base, slender, acuminate, entire or sparingly glandular on the margins, reflexed after anthesis; stamens 5–10, usually 5; anthers pink; styles 3–5, surrounded at the base by tufts of pale hairs. Fruit obovate or rarely short-oblong, bright reddish purple marked by small scattered pale dots, 1–1.6^{cm} long, 8–12^{mm} wide; calyx sessile, with a broad shallow cavity and spreading lobes, their tips mostly deciduous from the ripe fruit; flesh thin, yellow, juicy, pleasantly acid; nutlets three to five, thin, ridged on the rounded back with a low ridge, 6–8^{mm} long.

A tree 5–8^{m} in height with a trunk 1–2^{m} long and 1–2^{dm} in diameter, covered with dark gray bark separating into thin plates, 2–6^{cm} long and 1–2^{cm} wide, in falling disclosing the yellow inner bark, and dividing into several ascending branches forming an oblong or pyramidal crown resembling that of a pear tree; or often shrubby with numerous stems spreading into small clumps; ultimate branchlets rough, zigzag, covered with small twigs, dark dull red-brown and marked by small pale lenticels during their first season, dark gray-brown the following year and unarmed or armed with slender nearly straight dull red-brown ultimately ashy gray spines 3–4^{cm} long. Flowers early in May. Fruit ripens the first of September and soon falls and decays.

Dry open places, wood borders and along the margins of the high banks of streams. Common and generally distributed in the neighborhood of Chicago. Mokena, July 1900, May and September 1901, Barrington, May and September 1901, Glendon Park, May and September 1901, Tinley Park, May and September 1901, Joliet, May and September 1902, *E. J. Hill*; Joliet, *H. C. Skeels*, May 1902, Fort Sheridan, May and September 1902, *E. J. Hill.*

Crataegus cyanophylla, n. sp.—Glabrous except the upper surface of young leaves. Leaves oblong-ovate, acuminate, usually rounded or rarely truncate or cuneate at the broad base, sharply and often doubly serrate, with straight or incurved glandular teeth, and more or less divided into four or five pairs of spreading acuminate lobes; bright bronze-red when expanding; nearly half grown when the flowers open and then membranaceous, pale blue-green tinged with red and roughened on the upper surface by short pale hairs; at maturity thin, smooth, distinctly blue-green, darker on the upper than on the lower surface, 3–6^{cm} long, 2.5–5^{cm} wide, frequently as broad as long, with thin midribs and very slender prominent veins extending to the points of the lobes; petioles slender, slightly grooved, sparingly glandular, 1–3^{cm} in length; stipules linear to oblong-obovate, acute, glandular, turning pink in fading, caducous; leaves on vigorous leading shoots often elliptical, concave-cuneate at the base, long-pointed, coarsely serrate, more deeply lobed than the leaves of fertile branchlets, 7–8$^{\mathrm{cm}}$ long, 5–6$^{\mathrm{cm}}$ wide, with stout petioles wing-margined above the middle and 2–4$^{\mathrm{cm}}$ long, and foliaceous lunate coarsely glandular-serrate persistent stipules. Flowers 1.2–1.8$^{\mathrm{cm}}$ in diameter on slender pedicels in narrow 8–12-flowered thin-branched compound corymbs; bracts and bractlets linear, glandular, mostly deciduous before the flowers open; calyx tube narrowly obconic, the lobes gradually narrowed from the base, acuminate, tipped with minute red glands, entire or occasionally slightly glandular-serrate, reflexed after anthesis; stamens 5–10, usually 5, sometimes only 2 or 3 bearing anthers; anthers small, reddish pink; styles 3–5, generally 4, surrounded at the base by tufts of white hairs. Fruit on slender pedicels, in pendent drooping few-fruited clusters, subglobose to short-oblong, slightly four-angled, abruptly rounded at the ends, dark reddish purple marked by many small pale lenticels, 1–1.6$^{\mathrm{cm}}$ long, 9–15$^{\mathrm{mm}}$ wide; calyx sessile, with a narrow shallow cavity and slightly serrate erect or incurved lobes, bright red on the upper side below the middle, usually persistent on the ripe fruit, flesh thin, yellow, firm and rather dry, insipid, slightly bitter; nutlets 3–5, usually 4, rounded at the ends, prominently ridged on the back with a broad, often grooved ridge 6–8$^{\mathrm{mm}}$ long.

A bushy or occasionally treelike shrub 3–4$^{\mathrm{m}}$ in height with slender stems covered with pale gray bark, often spreading into broad thickets, ascending branches forming an oblong head and thin nearly straight branchlets, light orange-green and marked by many small pale lenticels when they first appear, dull light reddish-brown at the end of their first season, light gray-brown the following year, and armed with numerous dull chestnut-brown ultimately gray mostly short stout curved spines tapering abruptly at the apex, and often only 1.5$^{\mathrm{cm}}$ in length, or occasionally slender and 3–3.5$^{\mathrm{cm}}$ long. Flowers during the first half of May. Fruit ripens at the end of September or early in October and does not fall until after the leaves or until the beginning of November.

Dry upland pastures on the borders of woods, Mokena, September 1899, May 1900, Bremen and Orland, October 1901, May 1902, Joliet, May and September 1902, Oak Forest, September 1902, *E. J. Hill;* Joliet, *H. C. Skeels*, May 1902.

Crataegus trachyphylla, n. sp.—Leaves oval to elliptical and acuminate, rounded or broadly cuneate, or on leading shoots rarely subcordate at the entire base, sharply often doubly serrate above, with straight glandular teeth, and slightly divided above the middle into short acuminate spreading lobes; nearly half-grown when the flowers open and then dark blue-green tinged with red and roughened on the upper surface by short rigid white hairs and glabrous to the lower surface; at maturity very thin, dull bluish green and scabrate above, pale bluish green below, $5-6.5^{\mathrm{cm}}$ long, $3.5-5^{\mathrm{cm}}$ wide, often nearly as broad as long, with thin midribs and very slender primary veins extending obliquely to the points of the lobes; petioles slender, grooved, villose on the upper side early in the season, becoming glabrous, glandular, with small red stalked glands, mostly deciduous before autumn; stipules linear, acuminate, often somewhat falcate, glandular, turning reddish before falling, caducous. Flowers 1.8^{cm} in diameter on long slender pedicels, in broad many-flowered thin-branched compound corymbs; bracts and bractlets linear to lanceolate, glandular, turning red in fading, mostly persistent until after the flowers open; calyx tube broadly obconic, glabrous, the lobes slender, acuminate, coarsely glandular-serrate, usually only below the middle, glabrous on the outer, villose on the inner surface, reflexed after anthesis; stamens 5–7, generally 5; anthers pale pink; styles 4 or 5. Fruit drooping on long slender pedicels, in few-fruited clusters, obovate, full and rounded at the apex, gradually narrowed to the base, and often furnished on one side with a basal protuberance, crimson, lustrous, marked by small pale dots, $1.3-1.9^{\mathrm{cm}}$ long and $1.2-1.5^{\mathrm{cm}}$ wide; calyx sessile with a narrow shallow cavity and enlarged coarsely serrate spreading and incurved lobes bright red on the upper side below the middle, often deciduous from the ripe fruit; flesh thin, nearly white, acidulous, juicy; nutlets 4 or 5, thin, acute at the ends, irregularly ridged and often grooved on the back, about 7^{mm} long.

A tree 5^{m} in height with a trunk 2^{m} long and 1.5^{dm} in diameter covered with close dark gray bark divided by narrow fissures into numerous thin plate-like scales, ascending branches forming a narrow oblong head, and slender zigzag branchlets, dark orange color and marked by numerous small pale lenticels when they first appear, light orange-brown and very lustrous at the end of their first season, light gray-brown the following year, ultimately ashy gray, and armed with numerous stout slightly curved light chestnut-brown shining spines 2–4^{cm} in length. Flowers from the 1st to the 10th of May. Fruit ripens the middle of September and soon falls.

Drift hills in clay soil, Mokena, September 26, 1900, May, June and September 1901, and May and September 1902, *E. J. Hill.*

Well distinguished in this group by the shape of the very thin scabrous leaves and pyriform fruits.

CRATAEGUS EGANI Ashe, Jour. Elisha Mitchell Sci. Soc. 17^1:15. 1900.

Bremen, October 1901; Egandale, Highland Park, May, September and October 1902; Highland Park and Tinley Park, May and September 1902, *E. J. Hill;* Mokena, September 1902, *C. S. Sargent.*

Stamens 10.

Crataegus sextilis, n. sp.—Glabrous with the exception of the hairs on the upper surface of the young leaves. Leaves short-ovate, acute, rounded, cuneate, or particularly on vigorous shoots cordate at the wide entire base, finely serrate above, with straight or incurved glandular teeth, and deeply divided into 5 or 6 pairs of spreading acuminate lobes; when they unfold deeply tinged with red, covered above with soft white hairs, and glabrous below; at maturity thin but firm in texture, dull bluish green and scabrate on the upper surface, paler on the lower surface, 3.5–4.5^{cm} long, 3.5–6^{cm} wide, and often wider than long, with slender yellow midribs and thin primary veins extending obliquely to the points of the lobes; petioles slender, often slightly wing-margined at the apex, grooved, sparingly glandular, particularly while young, from 2–3^{cm} in length; stipules linear to lanceolate, glandular, caducous. Flowers 1.3–1.5^{cm} in diameter on long slender pedicels, in compact mostly 10-flowered thin-branched glabrous compound corymbs; bracts and bractlets linear, glandular, small, usually deciduous before the flowers open; calyx tube narrowly obconic, yellow-green, the lobes narrow, acuminate, entire or slightly serrate, sparingly glandular; stamens 10; anthers pink; styles usually 3, surrounded at the base by a broad ring of pale tomentum. Fruit on slender pedicels in drooping few-fruited clusters, subglobose to short-oblong, scarlet, lustrous, 1.2–1.4^{cm} in diameter; calyx sessile, with a narrow shallow cavity and small spreading closely appressed lobes usually deciduous from the ripe fruit; flesh thick, succulent, yellow; nutlets usually 3, broad, acute at the ends, very prominently ridged on the back, with a high rounded ridge, 7^{mm} long.

A shrub $2–3^{m}$ in height, with slender nearly straight branchlets, light yellow-green and marked by many small pale lenticels when they first appear, light red-brown and lustrous at the end of their first season, lighter-colored the following year and ultimately ashy-gray, and unarmed or armed with rather stout straight or slightly curved red-brown shining spines $1–3^{cm}$ in length; winter-buds globose covered with bright red shining scales, only 2^{mm} in diameter. Flowers about the middle of May. Fruit ripens from the 20th of August to the 1st of September, and immediately falls and decays.

Near Lake Zurich, September 1899, May and September 1901; Thatcher's Park, May, August and September 1900, May and August 1901; Maywood, August 1900, May and August 1901; Beverly Hills, June and August 1901, June 1902; Oak Forest, September 1902, *E. J. Hill.*

Well distinguished from the other species of this group in Illinois by the early ripening fruit which matures and drops a few days before the fruit of *Crataegus mollis* Scheele, ripens in the same region.

Crataegus paucispina, n. sp.—Leaves oblong-ovate, acuminate, rounded, concave-cuneate to truncate or subcordate at the entire base, sharply doubly serrate above, with straight glandular teeth and deeply divided into 4 or 5 pairs of acute lateral lobes spreading or pointing toward the apex of the leaf; about half-grown when the flowers open, and then light yellow-green and slightly roughened above by short white hairs and paler and glabrous below; at maturity membranaceous, dark blue-green and scabrate on the upper surface, light blue-green on the lower surface, $6–8^{cm}$ long, $4–6^{cm}$ wide, with slender yellow midribs and thin primary veins extending obliquely to the points of the lobes; petioles slender, slightly grooved, usually destitute of glands, tinged with purple in the autumn, $2–4^{cm}$ in length; stipules linear, acuminate, glandular, with large dark glands, reddish, caducous. Flowers $1.5–1.8^{cm}$ in diameter on slender pedicels covered with broad spreading hairs, in broad 12–20-flowered thin-branched slightly villose compound corymbs; bracts and bractlets linear to oblong-obovate, glandular, red, mostly persistent until after the flowers open; calyx tube narrowly obconic, glabrous, dull green, the lobes narrow, acuminate, glandular-serrate, with small dark red stipitate glands, glabrous on the outer, pubescent on the inner face, reflexed after anthesis; stamens 10; anthers bright reddish-purple; styles 4 or 5, surrounded at the base by tufts of pale hairs. Fruit on slender glabrous pedicels in drooping clusters, pyriform to globose-pyriform, crimson or purplish, marked by many small pale dots, slightly pruinose, 1.2–1.7^{cm} long, 1.2–1.5^{cm} wide; calyx small, with an arrow deep cavity and reflexed and appressed or erect and incurved serrate lobes, dark red on the upper side below the middle, often wanting from the ripe fruit; flesh thin, yellow, juicy, acid and edible; nutlets 4 or 5, thin, acute at the ends, rounded and slightly grooved or obscurely ridged on the back, 6–7^{mm} long.

A tree 5–8^{m} in height with a trunk 1.5–2^{m} long and 1–1.5^{dm} in diameter, covered with dark gray or blackish bark, separating into thin plate-like scales, numerous branches forming a round-topped head and slender zigzag branchlets, dark yellow-green and marked by many small pale lenticels when they first appear, dark dull reddish-brown at the end of their first season, olive gray in their second year, and ultimately dark gray-brown, and armed with small straight light red-brown shining spines usually only about 1.8^{cm} in length; winter-buds subglobose to short-oblong, large and conspicuous, 3–4^{mm} in diameter, covered with dark chestnut-brown lustrous scales slightly scarious on the margins. Flowers early in May. Fruit ripens from the 8th to the 15th of September and soon falls.

Woods and river banks in dry clay soil, Maywood, September 1899, May 1900, September 1901, May and September 1902, *E. J. Hill* and *C. S. Sargent*, September 1901.

Stamens usually 20.

Crataegus tarda, n. sp.—Leaves broadly ovate, acuminate, cuneate or rounded or rarely truncate at the wide base, sharply often doubly serrate, with straight glandular teeth and divided into 4 or 5 pairs of short broad acute lobes; about half-grown when the flowers open and then membranaceous, pale green more or less tinged with red and roughened above by short pale hairs, glabrous below, at maturity thin but firm to subcoriaceous, dark bluish green and smooth or scabrate on the upper surface, pale on the lower surface, 4–7^{cm} long, 4–6^{cm} wide, sometimes broader than long, with slender prominent midribs and thin but conspicuous primary veins arching obliquely to the points of the lobes; petioles slender, wing-margined at the apex, grooved, glandular, with numerous dark glands, mostly deciduous before autumn, 2.5–3^{cm} in length; stipules oblong-obovate rounded at the apex, glandular, tinged with red, large and conspicuous, usually persistent after the flowers open. Flowers 1.8–2.4^{cm} in diameter on slender glabrous or sparingly villose pedicels in 8–12-flowered thin-branched compound corymbs; bracts and bractlets lanceolate to oblong-obovate, acute, glandular; calyx tube broadly obconic, pale green, pubescent to glabrate, the lobes gradually narrowed from the base, wide, elongated, tipped with minute dark glands, finely glandular-serrate, glabrous on the lower, puberulous on the upper surface; stamens 10–20, usually 20; anthers pinkish purple; styles 3–5, usually 5, surrounded at the base by tuft of white hairs. Fruit on short glabrous pedicels, in compact few-fruited drooping clusters, oblong to subglobose, bright scarlet marked by numerous small pale lenticels, becoming crimson and soft and succulent when fully ripe, 1.2–1.6^{cm} long, 1.1–1.4^{cm} wide; calyx sessile, with a narrow shallow cavity and enlarged serrate spreading or erect lobes mostly deciduous from the ripe fruit; flesh thin, sweet, yellow; nutlets 3–5, usually 4 or 5, thin, acute at the ends, prominently ridged, with a thin narrow ridge or sometimes rounded and slightly grooved on the back.

A shrub 2–3^{m} in height with numerous small stems forming narrow-topped bushes, or when growing in the woods under the shade of other trees sometimes arborescent in habit with a well developed trunk and 4–5^{m} tall; branchlets stout, slightly zigzag, dark orange-green marked by many small lenticels when they first appear, bright red-brown and lustrous at the end of their first season, dark gray or gray-brown the following year, and armed with many very stout slightly curved abruptly pointed bright chestnut-colored shining ultimately gray spines 2–5^{cm} long. Flowers early in May. Fruit ripens at the end of September or early in October and remains on the branches with the leaves for another month.

Upland pastures, the borders of woods and the high banks of streams usually in hard clay soil, Barrington, June and September 1899, May 1901, Chicago Heights, May and October 1901, Orland, October 1901, May 1902, Mokena, May and September 1902, *E. J. Hill.*

Resembling superficially *Crataegus cyanophylla*, *Crataegus tarda* differs from that species in its soft succulent fruit, in its more numerous stamens, and in the usually broader and thicker light green leaves.

Crataegus Ferrissi Ashe, Jour. Elisha Mitchell Sci. Soc. $\mathbf{17}^{2}$:11. 1901.

Highland Park, May, September and October 1902, *E. J. Hill.*

Crataegus lucorum Sargent, Bot. Gaz. **31**:227. 1900; Silva N. Am. **13**:125. *pl. 679.*

Banks of sloughs near Barrington; Fort Sheridan, *E. J. Hill.* May and September 1902.

COCCINEAE.

Stamens 10.

Anthers pale yellow.

Crataegus praecoqua Sargent, Rhodora **5**: —. 1903.

Crataegus praecox Sargent, Rhodora **3**:27. 1901 (not *Crataegus Oxyacantha praecox* Loudon).

Wildwood, August 1894, May 1896, May, July and September 1899, September 1900; Barrington, May, June and September 1899; Glenwood, May, June and September 1899, May 1901; Glendon Park, May, August and September, *E. J. Hill,* 1900; Glendon Park, *C. S. Sargent,* September 1899.

Crataegus subrotundifolia, n. sp.—Leaves rhombic to broadly ovate, acute or acuminate at the apex, cuneate or rounded below, finely and often doubly serrate, with straight or incurved gland-tipped teeth, and divided above the middle into 3 or 4 pairs of short acute lobes; more than half-grown when the flowers open and then membranaceous, light yellow-green and covered on the upper surface with long white hairs and paler and glabrous on the lower surface, at maturity thin but firm in texture, glabrous, dark green and lustrous above, light yellow-green below, $3.5-4^{\mathrm{cm}}$ long, $2.5-4.5^{\mathrm{cm}}$ wide, often wider than long, with stout midribs and 3 or 4 pairs of prominent primary veins extending very obliquely to the points of the lobes; petioles stout, usually wing-margined to below the middle, deeply grooved, glandular with numerous dark glands mostly deciduous before autumn, often bright rose color late in the season on the lower side like that of the base of the midribs, $1-2^{\mathrm{cm}}$ in length; stipules linear, glandular, reddish, caducous; on vigorous shoots leaves sometimes oblong-ovate, more deeply lobed and more coarsely serrate than on fertile branchlets, concave-cuneate below and gradually narrowed into the broadly winged petioles, $5.5-6^{\mathrm{cm}}$

long, 4–5^{cm} wide. Flowers 1.5–1.6^{cm} in diameter on long slender slightly hairy pedicels, in 7–10-flowered compact thin-branched compound corymbs; bracts and bractlets linear to oblong-obovate, acute or rounded at the apex, glandular, with large dark red glands, reddish, large and conspicuous, mostly persistent until after the flowers open; calyx tube broadly obconic, the lobes gradually narrowed from the base, wide, elongated, acuminate, glandular-serrate, with stipitate light red glands, glabrous on the outer, densely villose on the inner face, reflexed after anthesis; stamens 10; anthers pale yellow; styles 2–4, usually 3, surrounded at the base by a broad ring of pale tomentum. Fruit on slender glabrous or slightly hairy pedicels, in drooping few-fruited clusters, short-oblong, full and rounded at the ends, dark crimson, marked by many large pale dots, 1.6–1.8^{cm} long, about 1.5^{cm} wide; calyx sessile, with a broad shallow cavity and spreading serrate lobes villose on the upper side; flesh thick, yellow, dry and mealy; nutlets 2–4 broad, full and rounded at the ends, prominently ridged on the back, with a very high wide deeply grooved ridge, 7^{mm} long.

A shrub 2 to 3^{m} tall, with numerous stems spreading into small thickets, or rarely a small bushy tree 5^{m} in height, with a broad spreading top; branchlets slender, zigzag, dark orange-green and marked by oblong pale lenticels when they first appear, light red-brown and lustrous during their first season, becoming light or dark gray-brown the following year, and armed with numerous stout straight or slightly curved bright chestnut brown shining spines 2.5–5^{cm} in length. Flowers about the middle of May. Fruit ripens the first of October.

Shores of Lake Zurich, May, September and October 1901; dry woods near Honey Lake, Lake county, October 1901, *E. J. Hill.*

This addition to the COCCINEA group differs from *Crataegus coccinea rotundifolia* Sargent, of the St. Lawrence valley and the northeastern states in its thinner and usually smaller leaves villose while young on the upper surface by the villose covering on the upper side of the calyx-lobes, and by its usually smaller fruits.

TOMENTOSAE.

Stamens 20.

Anthers rose color or pink.

CRATAEGUS TOMENTOSA Linnaeus.

Common.

Crataegus vegeta, n. sp.—Leaves elliptical, acuminate, gradually narrowed and concave-cuneate at the entire base, finely often doubly serrate above, with straight glandular teeth, and slightly divided above the middle into numerous short acute lobes; nearly fully grown when the flowers open and then membranaceous, dark yellow-green and roughened above by short rigid pale hairs, and densely pubescent below; at maturity thin but firm in texture, dark dull green and scabrate on the upper surface, pale and pubescent on the lower surface along the slender midribs and 5 or 6 pairs of thin primary veins arching obliquely to the points of the lobes, 7.5–10^{cm} long, 4.5–6^{cm} wide; petioles slender, broadly wing-margined at the apex by the decurrent base of the leaf-blades, grooved, villose on the upper side early in the season, becoming glabrous and rose color in the autumn, 1.5–2^{cm} in length; stipules linear, acuminate, rose color, small, caducous. Flowers 1.5–1.8^{cm} in diameter on long slender villose pedicels, in usually 10–12-flowered thin-branched hairy compound corymbs; bracts and bractlets linear to linear-obovate, acute, glandular, becoming reddish before falling, mostly persistent until after the flowers open; calyx tube narrowly obconic, villose like the slender acuminate glandular-serrate lobes, reflexed after anthesis; stamens 20; anthers small, light pink or red; styles 2 or 3, usually 3. Fruit on slender elongated rigid slightly villose pedicels, in few-fruited erect clusters, subglobose, scarlet, lustrous, marked by small, pale dots, 9–10^{mm} in diameter; calyx prominent with a short tube, a narrow deep cavity, and spreading reflexed serrate lobes; flesh thin, yellow, dry and mealy; nutlets 2 or 3, full and rounded at the ends, 6^{mm} long and nearly as broad, prominently ridged on the back, with a high grooved ridge, the dorsal cavities broad and deep.

A tree 7-8^{m} in height with a tall straight trunk sometimes 2^{dm} in diameter, stout wide-spreading branches forming a symmetrical round-topped head, and very slender nearly straight branchlets light orange-green and marked by many large pale lenticels when they first appear, bright red-brown and lustrous at the end of their first season, darker the following year, and unarmed or sparingly armed with slender nearly straight dark purple shining spines about 4^{cm} in length; winter-buds ovate to subglobose, light chestnut color, lustrous, 4-5^{mm} long, their inner scales accrescent, bright red and very conspicuous as the leaves unfold. Flowers at the end of May. Fruit ripens late in September.

Oak woods in moist rich soil near the bank of the Calumet river, at Calumet, *E. J. Hill*, May 27 and September 27 1901; *C. S. Sargent*, September 1901.

Crataegus Gaultii, n. sp.—Leaves elliptical to suborbicular, acute or rounded at the apex, concave-cuneate or rounded at the entire base, coarsely doubly serrate above, with straight glandular teeth, and occasionally slightly divided above the middle into short acute lobes; nearly fully grown when the flowers open and then very thin, light yellow-green and sparingly villose above, pale and slightly pubescent below; at maturity thin but firm in texture, glabrous, dark dull green on the upper surface, pale on the lower surface, $6–9^{cm}$ long, $5–7^{cm}$ wide, with stout yellow midribs deeply impressed above and 6 or 7 pairs of primary veins extending obliquely to the points of the lobes; petioles stout, wing-margined usually to below the middle by the decurrent base of the leaf-blades, villose on the upper side early in the season, with matted white hairs, becoming nearly glabrous, $1–2^{cm}$ long; stipules linear to linear-falcate, acuminate, glandular, with minute bright red stipitate glands, caducous. Flowers $1–5^{cm}$ in diameter on long slender slightly villose pedicels, in broad many-flowered thin-branched hairy compound corymbs with 3-flowered peduncles from the axils of the two upper leaves; bracts and bractlets linear, acuminate, glandular, turning red in fading, mostly persistent until the flowers open; calyx tube narrowly obconic, the lobes broad, acuminate, coarsely glandular-serrate, glabrous on the outer, villose on the inner face; stamens 18–20; anthers pale pink; styles 2 or 3. Fruit drooping on slender slightly hairy pedicels, in few-fruited clusters, subglobose to short-oblong, $1.2–1.4^{cm}$ in length; calyx sessile, with a broad deep cavity and spreading and appressed coarsely serrate lobes; flesh thick, yellow, soft and juicy; nutlets 2 or 3, full and rounded at the ends, about 1.2^{cm} long and nearly as wide, full and rounded on the back, with a high rounded ridge, the ventral cavities long, deep and narrow.

A tree $7–8^{m}$ in height with a trunk sometimes 2^{m} long and 2.5^{dm} in diameter, spreading branches forming a broad round-topped head, and slender slightly zigzag branchlets light yellow-green when they first appear, rather light red-brown, lustrous, and marked by many large pale lenticels at the end of their first season, becoming lighter-colored the following year and unarmed or armed with occasional straight slender dark purple shining spines 3–4 ^{cm} in length. Flowers at the end of May. Fruit ripens from the middle to the end of September.

Open pastures, Milton Township, Du Page county, *B. T. Gault*, May and September 1902; Glen Ellyn, June 1902, bluff-like banks of Hickory creek, Mokena, *E. J. Hill*, October 1900, May and June 1901.

Specimens collected by Dr. Hill at Mokena have smaller and rounder leaves, glabrous on the lower surface when the flowers open but otherwise very similar to those gathered by Mr. Gault in Milton which must be considered the type of this species.

Crataegus longispina, n. sp.—Leaves ovate to rhombic, acute or acuminate, gradually narrowed and cuneate at the entire base, coarsely and doubly serrate above, with straight gland-tipped teeth, and irregularly divided above the middle into short broad acute lobes; when the flowers open membranaceous, dark yellow-green, lustrous, and covered above with soft pale hairs, lighter-colored and slightly hairy along the midribs and veins below, at maturity very thick and coriaceous, dark yellow-green, lustrous, smooth and glabrous on the upper surface, light yellow-green and still slightly pubescent on the lower surface along the thick yellow midribs and 5 or 6 pairs of slender prominent primary veins, 6–8 ^{cm} long, 4–6 ^{cm} wide; petioles stout, wing-margined at the apex by the decurrent base of the leaf-blades, grooved, villose on the upper side, becoming glabrous, usually tinged with purple in the autumn like the lower part of the midribs; stipules linear, acuminate, glandular, small, caducous. Flowers about 1.2 ^{cm} in diameter on very long slender slightly hairy pedicels, in broad many-flowered thin branched villose compound corymbs; bracts and bractlets linear to linear-obovate, acuminate, elongated glandular with minute dark red stipitate glands, conspicuous, generally persistent until the flowers open; calyx tube narrowly obconic, villose toward the base, glabrous above, the lobes narrow, acuminate, coarsely glandular-serrate, glabrous on the outer, sparingly villose on the inner surface; stamens 20; anthers pale pink; styles 2 or 3. Fruit on stout glabrous red pedicels, in large many-fruited drooping clusters, subglobose, usually slightly wider than high, scarlet, lustrous, marked by few small dots 8–10^{mm} in diameter; calyx prominent, nearly sessile, with a narrow deep cavity and enlarged coarsely serrate reflexed and closely appressed lobes villose on the upper side, and usually persistent on the ripe fruit; flesh thin, yellow, dry and mealy, not becoming succulent; nutlets 2 or 3, full and rounded at the ends, 6^{mm} long, 7^{mm} wide, rounded and prominently grooved on the back, with a wide doubly grooved ridge, the ventral cavities broad and deep.

A shrub 1–2^{m} in height with stout branchlets, dark reddish-brown and marked by large pale lenticels when they first appear, light red-brown and very lustrous at the end of their first season, rather darker-colored and still lustrous the following year, and armed with numerous very stout nearly straight dark purple shining spines 6–9^{cm} long.

Sandy shores of Lake Zurich, *Hill* and *Sargent*, September 22, 1900, *E. J. Hill*, May and October 1901.

Crataegus rutila, n. sp.—Leaves broadly ovate to oval or suborbicular, rounded or abruptly narrowed and acute at the apex, rounded, concave-cuneate or rarely slightly cordate at the wide entire base, sharply and doubly serrate above, with straight glandular teeth, and divided above the middle into numerous small acuminate lobes; more than half-grown when the flowers open and then membranaceous, dark yellow-green, very smooth and glabrous above with the exception of numerous short white deciduous hairs on the upper side of the midribs, and pale and slightly pubescent or nearly glabrous below; at maturity subcoriaceous, dark yellow-green on the upper surface, light yellow and glabrous or puberulous on the lower surface, 4.5–7.5^{cm} long, 4.5–6.5^{cm} wide, with very stout yellow midribs deeply impressed above, 5 or 6 pairs of prominent primary veins, and thick conspicuous reticulate veinlets; petioles stout, wing-margined often to the middle by the decurrent base of the leaf-blades, covered on the upper side early in the season with short soft hairs, becoming glabrous, often tinged with purple in the autumn, 1–2.5^{cm} in length; stipules linear, acuminate, glandular, with small stipitate red glands, caducous. Flowers about 1.5^{cm} in diameter on long slender sparingly villose pedicels, in broad compact many-flowered thin-branched nearly glabrous compound corymbs; bracts and bractlets linear to oblong-ovate, acuminate, glandular and usually persistent until after the flowers open; calyx tube broadly obconic, glabrous, the lobes wide, acuminate coarsely glandular-serrate, glabrous on the outer, villose on the inner surface, reflexed after anthesis; stamens 20; anthers pink; styles 2 or 3, usually 2, surrounded at the base by small tufts of white hairs. Fruit drooping on slender glabrous pedicels, in few or many-fruited clusters, subglobose, orange-red, marked by occasional large pale dots, becoming crimson and lustrous when fully ripe, 8–10^{mm} in diameter; calyx prominent with a broad deep cavity and spreading and closely appressed lobes; flesh thin, yellow, soft and succulent; nuts usually 2, full and rounded at the ends, 6–7^{mm} long, often 5^{mm} wide, prominently ridged on the back, with a broad deeply grooved ridge, the ventral cavities very oblique, broad and deep.

A shrub or small tree sometimes flowering when not more than 1^{m} in height, with rather stout nearly straight branchlets, light orange-green and marked by small pale lenticels when they first appear, bright reddish brown and lustrous at the end of their first season, dark reddish brown the following year, and unarmed or armed with occasional stout nearly straight dark purple shining spines about 2.5^{cm} in length. Flowers from the 20th to the end of May. Fruit ripens from the first to the middle of October.

Pastures, Mokena, September and October 1900, May and June 1901, bluff bank of Thorn creek, Chicago Heights, May and October 1901, *E. J. Hill*; shores of Lake Zurich, *C. S. Sargent*, September 1900; Milton Township, Du Page county, *B. T. Gault*, May and September 1902.

Anthers pale yellow.

Crataegus laxiflora, n. sp.— Leaves obovate to ovate-oblong on leading shoots, acuminate, acute or broad and rounded at the apex, mostly gradually narrowed from near the middle to the rounded or cuneate entire base, sharply and doubly serrate above, with straight gland-tipped teeth, and divided toward the apex into 3 or 4 pairs of short acute lobes; about half-grown when the flowers open and then membranaceous, dark yellow-green, lustrous, smooth and glabrous with the exception of a few deciduous hairs near the base of the midrib on the upper surface, light yellow-green and glabrous on the lower surface; at maturity coriaceous, dark green and very lustrous above, light yellow-green below, 4–7^{cm} long, 3–4^{cm} wide, with stout yellow midribs and thin prominent primary veins extending obliquely to the points of the lobes; petioles stout, grooved, slightly wing-margined at the apex, pubescent on the upper side early in the season, soon glabrous, often tinged with red in the autumn, 1.5–2^{cm} in length. Flowers about 1^{cm} in diameter on long slender pedicels, in broad many-flowered thin-branched very lax villose compound corymbs; bracts and bractlets oblong-obovate to linear, acuminate, glandular, turning red in fading, generally deciduous before the flowers open; calyx tube narrowly obconic, thickly covered with long matted or spreading white hairs, the lobes broad, acuminate, coarsely glandular-serrate, with minute bright red stipitate glands, glabrous on the outer, slightly villose on the inner surface, reflexed after anthesis; stamens 18–20; anthers small, pale yellow; styles 2. Fruit on elongated slender glabrous pedicels, in long many-fruited gracefully drooping clusters, subglobose to short-oblong, bright orange-red, lustrous, marked by occasional large pale lenticels, about 8^{mm} in diameter; cavity of the calyx deep and narrow, the lobes early deciduous, leaving a ring-like border to the long tube; flesh thin, yellow, sweet, dry and mealy, hardly becoming soft and succulent; nutlets 2, full and rounded at the ends, 6^{mm} long, 5–6^{mm} wide, prominently grooved on the back, with a wide doubly grooved ridge; ventral cavities very broad and deep, extending nearly the entire length of the nutlet.

A small tree 3–8^m high, with slender slightly zigzag branchlets, light orange-green and glabrous when they first appear, bright red-brown, very lustrous and marked by occasional small dark lenticels at the end of their first season, becoming darker the following year, and armed with numerous slender straight bright purple shining spines 3–4^{cm} in length. Flowers during the last week of May. Fruit ripens the middle of October.

Banks of the north branch of Hickory Creek at Marley, September 1895, May and October 1897; upland pastures, Mokena, September and October 1900, May and September 1901, *E. J. Hill.*

Stamens 10 or fewer.

Anthers pink.

Crataegus divida, n. sp.— Leaves oblong-ovate, concave-cuneate or rounded at the gradually narrowed entire base, coarsely doubly serrate above, with straight gland-tipped teeth, and very slightly and irregularly divided above the middle into small acute lobes; more than half-grown when the flowers open and then dark green and roughened above by shining white hairs, and paler and glabrous below; at maturity thin but firm in texture, light bluish-green and scabrate on the upper surface, pale on the lower surface, 5.5–8^{cm} long, 4.5–5.5^{cm} wide, with slender yellow midribs deeply impressed on the upper side, and 5 or 6 pairs of thin primary veins extending very obliquely to the points of the lobes; petioles stout, wing-margined at the apex, grooved, sparingly villose early in the season, becoming glabrous and dark purple, glandular with minute scattered dark glands, 2.5–3^{cm} in length. Flowers 1.5–2^{cm} in diameter on long slender pedicels, in broad many-flowered thin-branched glabrous compound corymbs; bracts and bractlets linear, acuminate, slightly glandular, reddish, mostly deciduous before the flowers open; calyx tube broadly obconic, glabrous, the lobes abruptly narrowed at the base, wide, acuminate, tipped with minute red glands, coarsely glandular-serrate, glabrous on the outer and villose on the inner face; stamens 5–10; anthers pink; styles 2 or 3. Fruit on glabrous red pedicels in drooping few-fruited clusters, short-oblong to subglobose, crimson, lustrous, marked by small pale lenticels, 1–1.2^{cm} in diameter; calyx prominent with a broad deep cavity and much enlarged coarsely serrate spreading lobes, dark red on the upper side below the middle, slightly villose toward the apex, generally persistent on the ripe fruit; flesh thin, yellow, soft and succulent; nutlets 2 or 3, full and rounded at the ends, 7^{mm} long, 6^{mm} wide, prominently ridged on the back, with a broad high deeply grooved ridge, the ventral cavities broad and shallow.

A small round-headed tree, 4–5^{m} in height, with slender nearly straight branchlets, light orange-green and marked by small pale lenticels when they first appear, light reddish-brown and very lustrous at the end of their first season, and gray or light reddish-brown the following year, and armed with few very stout slightly curved bright chestnut-brown shining spines 3.5–4^{cm} long. Flowers about May 20th. Fruit ripens early in October, but is apt to wither on the tree.

Borders of woods on clay hills near Barrington, May, June and September 1899, Barrington village, May, June and September 1899, and May and October 1901, *E. J. Hill.*

Anthers light yellow.

Crataegus corporea, n. sp.—Leaves rhombic, acute at the apex, concave-cuneate at the entire base, finely serrate above, with straight gland-tipped teeth and usually slightly divided above the middle into several short broad acute lobes, about half-grown when the flowers open and then membranaceous, dark yellow-green and sparingly villose above, pale and glabrous below; at maturity subcoriaceous, glabrous, smooth and dark bluish green on the upper surface, light yellow-green on the lower surface, 5–7 ^{cm} long, 4.5–6 ^{cm} wide, with stout yellow midribs deeply impressed on the upper side and five or six pairs of prominent primary veins; petioles stout, wing-margined toward the apex, deeply grooved, slightly villose on the upper side early in the season, soon glabrous, 1–1.8 ^{cm} in length. Flowers 1.5 ^{cm} in diameter on long slender pedicels, in broad many-flowered thin-branched slighly villose compound corymbs; bracts and bractlets linear, acuminate, glandular, mostly deciduous before the flowers open; calyx tube broadly obconic, glabrous, the lobes wide, acuminate, coarsely glandular-serrate, with small stipitate bright red glands, glabrous on the outer, villose on the inner face, reflexed after anthesis; stamens 5–10; anthers pale yellow, surrounded at the base by small tufts of pale hairs. Fruit on stout dark red glabrous pedicels in many-fruited drooping clusters, subglobose, dark reddish purple, lustrous, marked by occasional pale dots, becoming very soft and succulent when fully ripe, and 1.5–2 ^{cm} in diameter; calyx prominent, with a broad deep cavity and spreading and closely appressed lobes villose and dark red on the upper side, often deciduous from the ripe fruit; flesh thick, yellow, sweet and juicy; nutlets 2 or 3, full and rounded at the ends, about 7 ^{mm} long and 6 ^{mm} wide, ridged on the rounded back, with a low wide ridge, the ventral cavities short and deep.

A shrub with slender stems 1–2 ^{m} in height, spreading into small thickets, and stout slightly zigzag branchlets light reddish-brown and marked by large pale lenticels when they first appear, light red-brown and very lustrous at the end of their first season, darker and still lustrous the following year, and ultimately gray tinged with red, and armed with stout nearly straight dark purple shining spines 7–9^{cm} long. Flowers from the 20th to the end of May. Fruit ripens at the end of September.

Gravelly shores of Lake Zurich, *Hill* and *Sargent*, September 22, 1900; *E. J. Hill*, May and September 1901.

ARNOLD ARBORETUM,
Jamaica Plain, Mass.

MITOSIS OF THE PRIMARY NUCLEUS IN SYNCHYTRIUM DECIPIENS.

Frank Lincoln Stevens and Adeline Chapman Stevens.

(WITH PLATES XVI AND XVII)

The fungus *Synchytrium decipiens* Farlow invades single cells of the hog peanut (*Falcata comosa* (L.) Kuntze) and there causes proliferation of the tissue until the host cell is imbedded in a gall of considerable size. The parasite is at first seen resting in the cytoplasm of the host cell and occupying it conjointly with the host nucleus of that cell. The parasite, growing more rapidly than the host cell in the early stage of its enlargement, soon comes to occupy the whole cell space, while the host nucleus slowly disappears. During further gall growth the parasitized cell becomes many times larger than when attacked. The cytoplasm of the parasite increases *pari passu*, continuing to fill completely the host cell. Increase in cytoplasm is accompanied by a corresponding growth of the Synchytrium nucleus. It thus happens that while the nucleus of the invading Synchytrium was at first very small, it later reaches proportions vastly larger than the nucleus of the host plant, larger even than the notoriously large nuclei found elsewhere in the plant kingdom. The maximum diameter of the embryo sac nuclei of flowering plants ranges in the neighborhood of 20-30μ and that of the vegetative nuclei from 5 to 9μ. The nucleus of this unicellular fungus parasite often attains a diameter of 35μ, with a nucleolus 11μ or more in diameter.

The vegetative period of the parasite is characterized by increase in size of both the fungus body and its nucleus. This period may be said to end and the reproductive period to begin with those processes which lead to separation of this mass of cytoplasm into numerous portions which are by further division to become swarm spores. The first step toward the separation of the cytoplasmic body is the division of this primary nucleus.

This process is of peculiar interest because of the large size of the nucleus, quite exceptional among the fungi, its peculiar rapid growth and subsequent division, and the problematic taxonomic position of the Chytridiales, which we may reasonably hope will be cleared up by cytological research. The very few investigations already published on species of this genus in no way detract from the interest of the problem. Two investigators, Dangeard ('90) and Rosén ('93), have reported results from *Synchytrium Taraxaci* DeB. & Wor., which, though not agreeing in detail, reveal conditions entirely unique. They are of such a nature as to demand further investigation and if possible reconciliation with current theories of the nucleus, which suffer violence if the conditions imperfectly reported by these authors really exist. Dangeard employed modern technique, although absolute alcohol and haematoxylin, his favorite fixative and stain, do not seem to be adapted to critical research in this group.

Dangeard describes the nuclear membrane of *Synchytrium Taraxaci* as granular, the nucleolus also being granular and quite spherical. He says that the nucleus divides by successive bipartition, a method of direct division. The membrane inflexes and the daughter nuclei become separated by constriction of the parent nucleus. He figures such division, showing two daughter nuclei together with their clumped chromatin masses grouped on adjacent sides, the parent chromatin group being evidently constricted, as is the remainder of the nucleus. Aside from this curious method of direct division, Dangeard states that the nucleus sometimes divides indirectly, and his *fig. 23* shows what he considers to be a type of mitosis. From both his text and figures it appears that this mitosis occurs in divisions later than the primary, and that both mitosis and direct division may occur side by side in the same cytoplasm, thus presenting a very unique condition, since it is usual in multinucleate masses of cytoplasm for the nuclei to divide not only by the same mode but also almost simultaneously. Dangeard does not claim to have followed the mitosis in Synchytrium through its phases, but he mentions it rather incidentally as a mode seen but not followed in edtail.

Rosén ('93) touched lightly upon *Synchytrium Taraxaci*, and his results agree with those of Dangeard to the extent that he describes a direct division in the primary nucleus. This division however is so different in type from that described by Dangeard that it certainly could not have been described or figured from the same structures. In the primary nucleus Rosén finds that the chromatin loops into a spirem, the nucleolus divides, the halves migrating to the forming daughter nucleus. The nucleus then constricts in the middle, thus completing a division of the nucleus in its spirem condition without the aid of the usual achromatic structures. He asserts that as successive divisions follow they assume more and more the character of mitosis, eventually presenting a typically mitotic division.

While discrepancies exist between these two authors regarding the details of the amitosis, they agree that mitosis is the exception and amitosis the rule; also that the primary division, *i. e.*, the first division of the one primitive nucleus of each sorus, is a direct division.

The present investigations have been exclusively concerned with *S. decipiens* Farl., and our results are directly comparable therefore with those of Dangeard and Rosén only in so far as different species of one genus may be expected to agree in cytological detail. However, the work on Fucus (Oltmanns, '89) and Albugo (Stevens, '99, '01) shows more specific cytological variation than *a priori* judgment would admit.

The caption of the present article, indicating that the primary division is mitotic, emphasizes one of the chief features of divergence between these results and those of Dangeard and Rosén. We may here indicate also that in affirming that the primary division may be mitotic we in no way set aside the possibility of its being sometimes, even frequently, amitotic. There are many peculiar structures to be found in the sori of Synchytrium, which it seems impossible to reconcile with universal mitotic division. A consideration of these leads to conclusions at variance again with those of Dangeard and Rosén regarding the details of the amitotic division. Discussion of these structures is reserved for a separate paper, the present one being limited to a description of a series of stages, all clearly pertaining to true mitosis in the primary nucleus.

De Bary and Woronin observed and have described in beautiful detail the entrance of Synchytrium into the host cell. From this point it is easy to follow the cytological changes. The cytoplasm of the invading parasite stains deeply, and is clearly recognized imbedded in the lighter cytoplasm of the host cell. For some time both the nucleus and the cytoplasm of the host cell persist, but eventually they disappear, the parasite in the meantime increasing rapidly in size. A moderately early stage of development is represented in *fig. 1*, which shows the granular, darkly staining mass of cytoplasm, spherical in form, and with a relatively large nucleus and nucleolus. Adjacent host cells exhibit nuclei and chloroplasts, thus admitting of comparison as to their relative size. At this and other early periods of development the nucleolus is large, usually solitary, homogenous in appearance, and surrounded by a thick darkly staining wall which is probably largely composed of a layer of linin laden with chromatin. Encasing the nucleolus is a mass of chromatin usually forming a continuous covering, and in places collected into irregular heaps and lumps. Occasional strands of chromatin connect the nucleolus, which is usually centrally placed, with the nuclear membrane. Chromatin is also found distributed in apparently disconnected globules of varying size, studded thickly over the inner surface of the nuclear membrane.

The parasite rapidly enlarges to occupy completely the host cell, which soon becomes enormous in size as gall-formation proceeds. A single host cell which normally averages less than 15μ in diameter after occupation by the parasite usually attains a diameter of 100μ or more. As the cell grows the nucleus grows, reaching at its maximum a diameter of 35μ. During this enlargement the character or structure of the nucleus changes somewhat. The nuclear membrane becomes thicker and more conspicuous. The globules of chromatin studding its inner surface increase in number and size, and more connections are established between the chromatin surrounding the nucleolus and that of the periphery.

The nucleolus follows the growth of the nucleus, enlarging to a diameter of about 14μ. Nucleolar inclusions in the form of homogenous globules of varying size imbedded in a granular matrix are more abundant than in earlier stages. A single cell of Synchytrium divested of its host envelope is exhibited in *fig. 2*. The nucleus has not yet reached full size, but is typical of this stage of development. It shows well the thick nuclear membrane, the peripheral chromatin, the connecting strands, and the nucleolar inclusions. *Fig. 3* shows a single more mature nucleus drawn to a larger scale. Here the chromatin is arranged in lumps, massed largely on one side of the nucleolus, while the inside of the wall is thickly beset with chromatin-bearing globules. The nucleolus is still more granular and the inclosed globules more numerous than in earlier stages. The whole dark central portion of the nucleolus must be interpreted as a vacuole, which, together with the increasing number and size of imbedded globules (dissolution products), indicates the disintegration of the nucleolus, a change further emphasized in *fig. 4*, where the nucleolus is almost entirely converted into the characteristic vacuoles. This change in the nucleus is the first visible sign of approaching mitosis. In the stages represented in *figs. 1, 2, 3, 4*, a large and remarkably clear area may be seen between the nucleolus and nuclear membrane, evidently a large vacuole created by the characteristic aggregation of the chromatin.

Up to this time the nuclear membrane has been sharp and distinct, even thick, the nucleolus large and conspicuous, the chromatin in irregular masses partaking in no way of the appearance of threads, and a large intranuclear vacuole has been constantly present.

All of this now changes. The membrane becomes gelatinous, the chromatin assumes a spirem form, and the nucleolus disappears. The nuclear membrane, previously thick and definite, first loses sharpness on its outer surface and is no longer to be seen as a definite wall. Dissolution begins from the outside. The nuclear region is long maintained, clearly mapped out, being now bounded by a layer of gelatinous consistency which stains more darkly with the orange G than does the surrounding cytoplasm. The replacement of the nuclear wall by this gelatinous substance is a process which can be followed closely from its inception (*fig. 5*) to the later stages of mitosis (*fig. 14*). The inner boundary of the nuclear wall remains definite until mitosis is well advanced (*fig. 10*). The first indication of the dissolution of the nuclear wall is evidenced by the darker staining of the cytoplasm immediately in contact with the wall (*fig. 4*). This darkly stained region rapidly grows to a layer of gelatinous consistency in which the cytoplasm is of finer mesh and tends to be more granular. Changes very similar to those noted accompany both dissolution and building up of walls in Albugo (Stevens, '99). As the character of the nuclear membrane changes a marked shrinkage in the size of the nucleus occurs, possibly directly induced by the altered osmotic relations. A decrease from 40 to 20 μ is not unusual in this first step toward mitosis. The nucleolus, dissolution of which had proceeded far in *fig. 3*, now completely disappears. The line bounding it, which seemed a husk of chromatin rather than a definite membrane, vanishes, and the nucleolar substance, which was much wasted by the one large and many small vacuoles, is no longer to be seen. Occasional small globules, staining like vacuoles of the nucleolus (*fig. 3*), may be found in the spirem and constitute the only remaining trace of the nucleolus (*fig. 7*).

The chromatin undergoes a change as striking as that of the membrane and nucleolus. Formerly coarse and lumpy (*fig. 3*), its globular masses become much more numerous and relatively smaller (*fig. 5*). They then appear to elongate, the numerous globules being replaced by rods crossed and tangled in inextricable confusion. *Fig. 6* represents a condition where the globules have partially changed to the elongate form, while *fig. 7* shows the completion of this phase, resulting in what must be regarded as the typical spirem of this primary division in *Synchytrium decipiens*. It is characterized by fine even threads of chromatin, uniformly distributed throughout the nucleus, yet tangled and intertwined in a most complicated way. The dots in the figure represent end views of the chromatin threads, and the lines the same from a side view. The slightest change in focus brings many others to view. It is particularly noticeable that no curving or looping is seen, the threads ever remaining straight and intersecting in acute angles.

Judging merely from the size of the nuclei, the critic may assert that *fig. 7* represents a stage intermediate between those of *figs. 1* and *3*, a criticism that is fully met, however, by further study of the figures, since neither the condition of the nuclear membrane nor of the nucleolus admits of the intercalation of any such condition as that shown in *fig. 7*. Moreover, the sorus is at its maximum when presenting the structure shown in *fig. 7*, which would not be the case if this were intermediate between *figs. 1* and *3*. Even if no more advanced stages were discovered, we see no escape from the conclusion that *fig. 7* represents the spirem and is a later development from such structures as are shown in *figs. 1*, *2*, *3*, etc. The fact that *fig. 6* is slightly smaller than *fig. 7* is explicable by the assumption that it is derived from a smaller resting nucleus. *Fig. 6* clearly represents a stage early in the dissolution of the nuclear membrane, likewise early in spirem formation. It must lie between *figs. 5* and *7*, and that without contradicting the general fact of a nuclear shrinkage throughout the mitosis. *Figs. 8–10* represent a progressive series of stages clearly more advanced than *figs. 4–6*. In these the boundary region is practically unchanged in character, though continually contracting with the diminution of the nucleus. The spirem threads as shown in *fig. 8* become slightly thickened, apparently by longitudinal fusion of separate rods. There is a tendency of the chromatin to accumulate in masses, though never partaking of that peculiar characteristic lumpy appearance shown in *figs. 3*, *4*. Vestiges of the nucleolus remain as in *fig. 7* throughout further stages of mitosis. *Fig. 9* shows, in a much more pronounced way, how the threads coalesce as they meet in the center. Meanwhile the size of the nucleus decreases. In *fig. 10* there is a distinct indication of an arrangement in spindle form, though many strands remain as yet apparently in no way connected with the developing spindle. From this series and numerous other similar stages seen by the writers, there remains no doubt that from the spirem the nucleus passes to a definite spindle formation. This spindle is intranuclear, thus agreeing with the nuclei of fungi generally. However, it is usual in the intranuclear formation of the spindle for the poles to originate in contact with the nuclear membrane, whereas in this case they are far from being so placed. As to the exact mode of spindle formation we can say nothing further than that the threads of the spirem group form themselves into a spindle. No centrosomes or polar radiations were distinguished in any stages of the mitosis.

During progress from the condition shown in *fig. 3* to that of *fig. 10*, a striking and remarkable change has occurred, in that the whole chromatin content has decreased largely. *Figs. 12* and *14* show a still greater reduction. All of the chromatin-bearing parts diminish, until, as in *fig. 11*, only a well marked spindle remains, bearing a few short chromosomes. In all early stages there seems to be a vast quantity of chromatin distributed at first throughout these globules, and later (*fig. 7*) on a linin network of large extent, while after the formation of the spindle the chromatin is insignificant in amount. There is here either a great condensation or an actual reduction in the amount of chromatin. Increase in the density of staining favors the former view, although the decrease in volume is too great to be attributed wholly to such a cause.

The nuclear membrane is gelatinized as early as the conditions shown in *figs. 5* and *6*. With the constant shrinkage of the nucleus it decreases in superficial area, but apparently not in volume, inasmuch as it constantly grows in thickness. Eventually the spindle, by the constant shrinkage of the gelatinous membrane, comes to lie in a narrow court surrounded by a broad dense zone of granular substance staining strongly with the orange G. This halo, clearly the residue of the altered nuclear membrane, is a conspicuous object in the field, though the nucleus itself is now very small, averaging 10 μ or less in length. The nucleolus persists unchanged in character from the condition shown in *fig. 10*, *i. e.*, it is similar to the nuclear vacuole shown in *fig. 3*.

A distinct view, slightly after metaphase, is given in *fig. 12*, showing the chromosomes at the two ends of the spindle. They are probably four in number, although we do not assert this with certainty. After the polar migration of the chromosomes the whole spindle lengthens much, giving a peculiar distorted figure similar to that found in the nuclei of *A. Bliti*, and the telophase is of similar nature to that described for that fungus (Stevens, '99). The spindle fibers fall together in the center and divide, giving rise to the independent daughter nuclei.

This mitosis agrees well in late anaphase with that of many other fungi, conspicuously so with Albugo. In many other respects it is unique. The early dissolution of the membrane and the persistence of its remains as a granular halo around the metaphase and anaphase figures is a new phenomenon, as is also the mode of spindle formation. The spirem also differs from any previously described, and the behavior of the nucleolus is unique; while the disposition of the chromatin in resting and early prophase conditions is exceptional.

The great size of the nucleus led to an inference that the mitosis would present, perhaps more clearly than any other type of fungus, the details of spindle formation. This inference was unfounded, since the shrinkage of the nucleus preparatory to mitosis reduces the spindle to moderate dimensions. Moreover the stages are rare to find. Hundreds of samples were examined showing no trace of mitosis, while a very few leaves of the host plant were found exhibiting good stages. When a block of good material is secured it gives abundant cases, however, to prove the existence of mitosis. Still, as there can be obviously only one primary division in each sorus it is an exceedingly slow task to complete a series. All of the figures represented come from sori bearing only one nucleus, and unquestionably represent primary division. Occasional views of the second and succeeding mitosis were had, but here the subject becomes much complicated and discussion is reserved for a later paper.

The significance of the facts observed, such as the enlargement of the nucleus and its subsequent shrinkage, the peculiarities of mitosis, the chromatin changes, etc., will be better interpreted when the other peculiarities in the cytology of this fungus are described. The Chytridiales have offered an open field for speculation heretofore, and have baffled definite judgment as to their nature and relationship. Fuller knowledge of their cytological peculiarities may lead to a more satisfactory condition.

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EXPLANATION OF PLATES XVI AND XVII.

All figures are from material killed in chrom-acetic acid and stained with Flemming's triple stain. The figures were sketched with an Abbé camera, using a Leitz $\frac{1}{12}$, ap. 1.30, giving an enlargement of 1790 diameters, with the exceptions of *figs. 1* and *2*, which were drawn from a Bausch and Lomb $\frac{1}{6}$, with a magnification of 750 diameters. Plate not reduced in reproduction.

PLATE XVI.

Fig. 1. One parasitized cell in early stage of development, showing large nucleus and nucleolus surrounded by granular cytoplasm; adjacent cells show nuclei and chloroplasts.

Fig. 2. Parasite nearly at end of growing period; nucleus heavy walled, vacuolate; chromatin distributed along nuclear wall, around the nucleolus, and on connecting strands.

Fig. 3. Single nucleus of a stage similar to but slightly later than *fig. 2*, and more highly magnified; nuclear vacuoles prominent, nucleolar substance giving way to vacuoles; chromatin on nuclear wall also arranged in irregular heaps around the nucleus; nuclear wall still definite and firm.

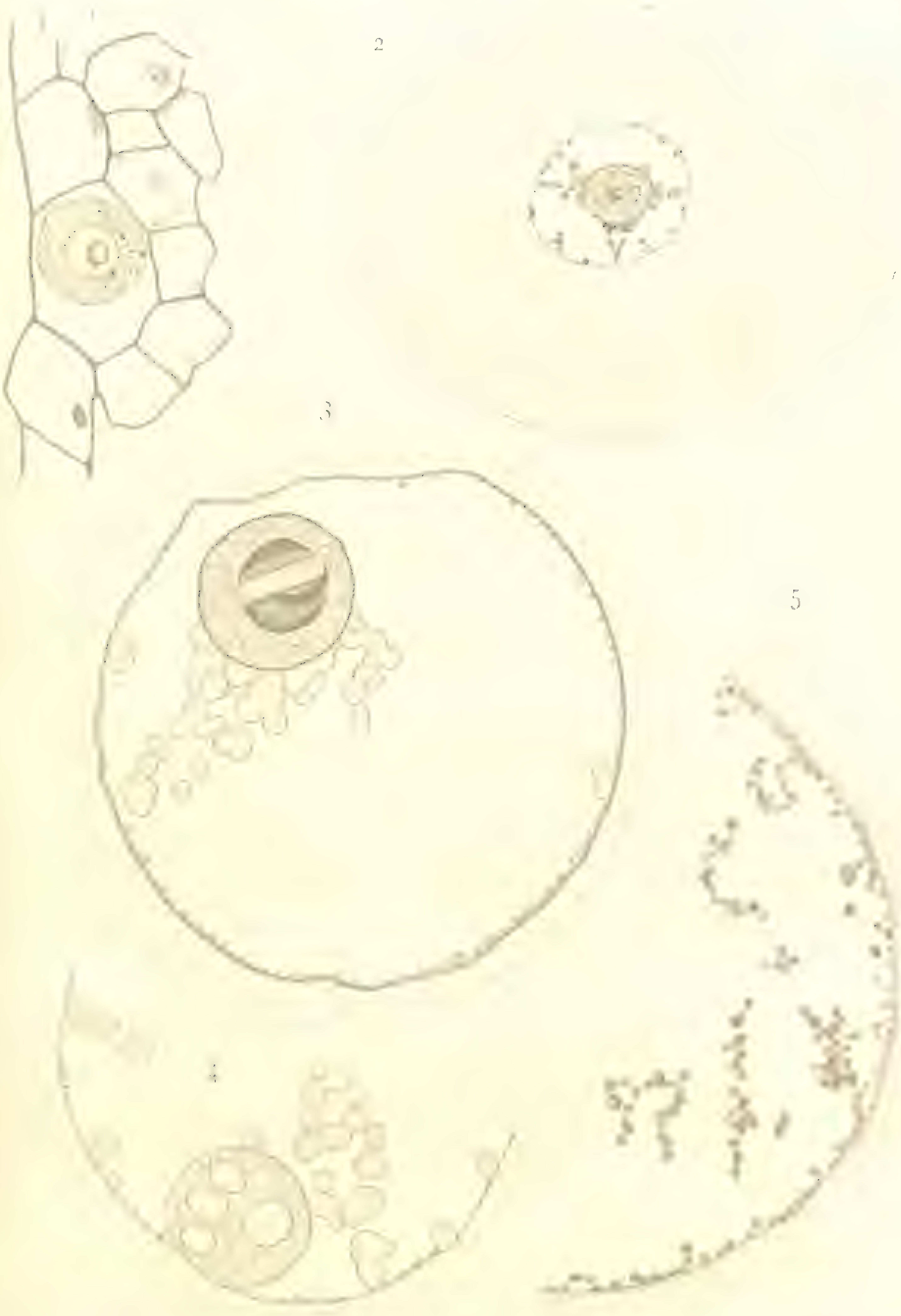
Fig. 4. Portion of nucleus slightly later, showing the continued wasting of the nucleolus and a somewhat more even distribution of chromatin.

Fig. 5. Portions of nucleus still later; nucleolus not present; the large chromatin lumps and globules of *fig. 4* have given place to more numerous and smaller ones which have also taken on a much more even distribution, thus largely obliterating the large conspicuous vacuole of earlier stages; the nuclear membrane is less distinct on its outer border.

PLATE XVII.

Fig. 6. The chromatin globules of earlier figures are assuming the rod-form; the nuclear membrane has softened from the outside inward, being now largely represented by a thick layer which stains darkly with the orange G.

Fig. 7. Chromatin rods entirely replace the globules of earlier stages; these rods intersect at sharp angles, often appearing as dots from end view; a nucleolus, similar in stain to the nucleolar vacuoles in *fig. 4*, is seen to the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6

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11

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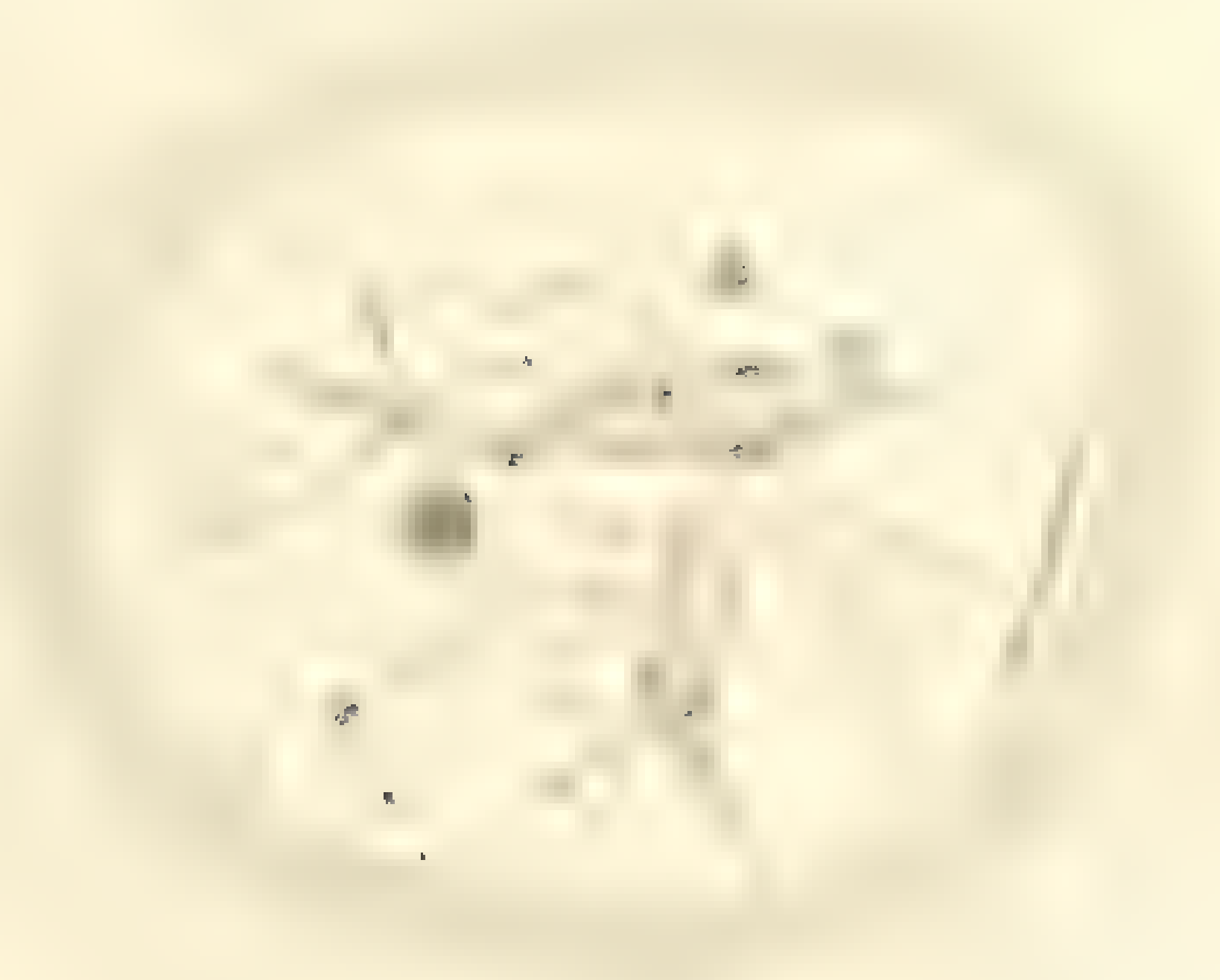

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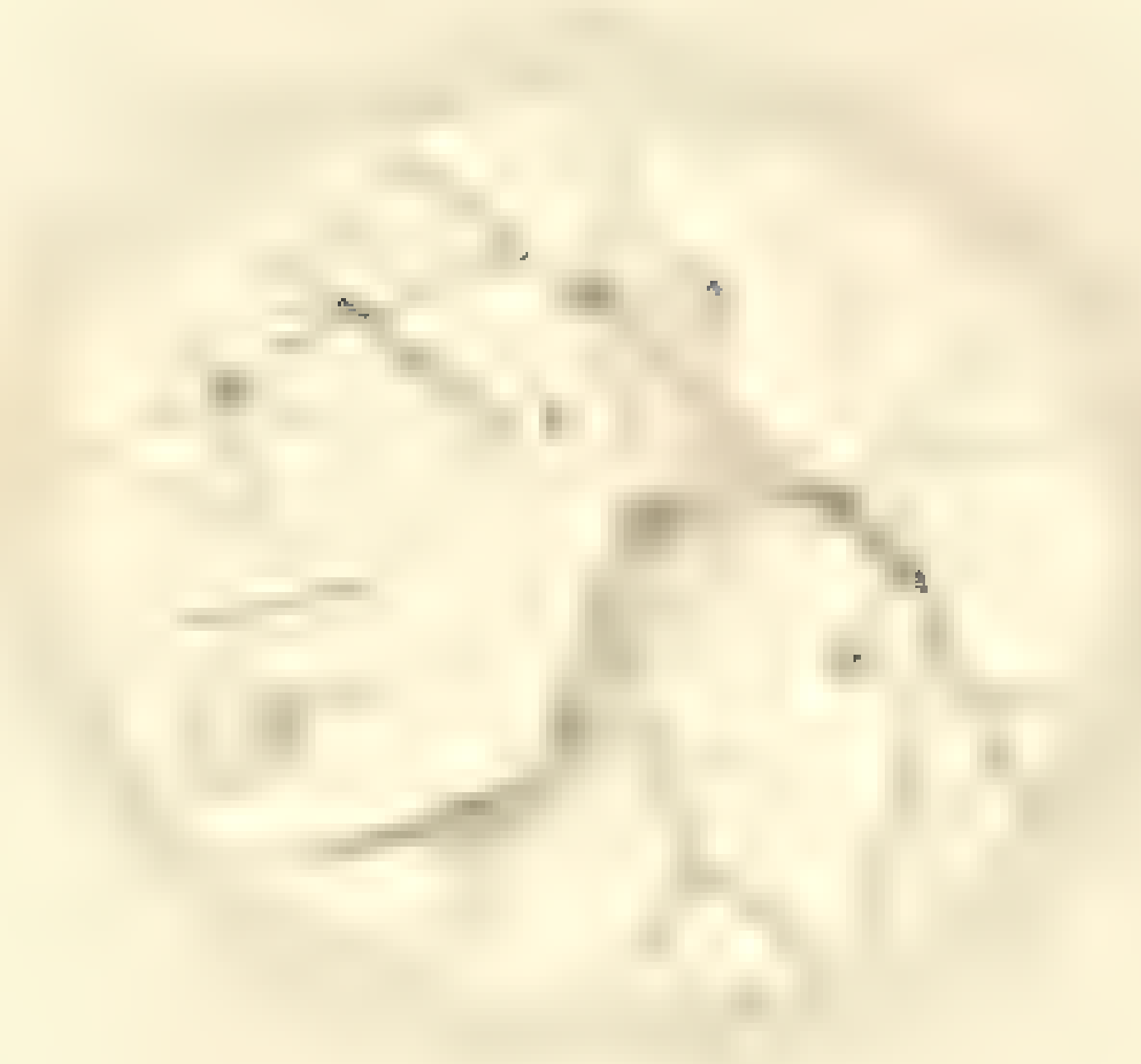

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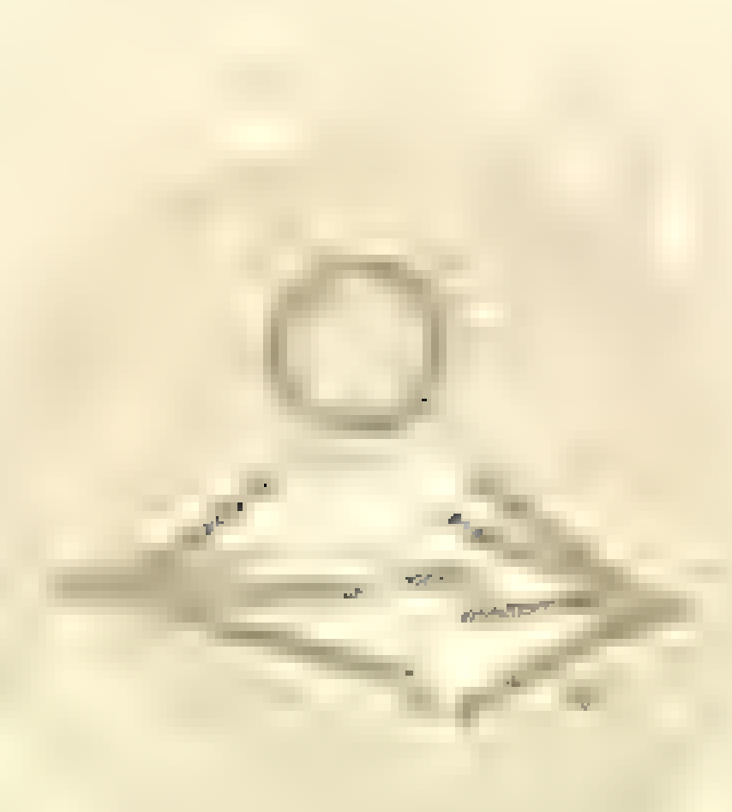
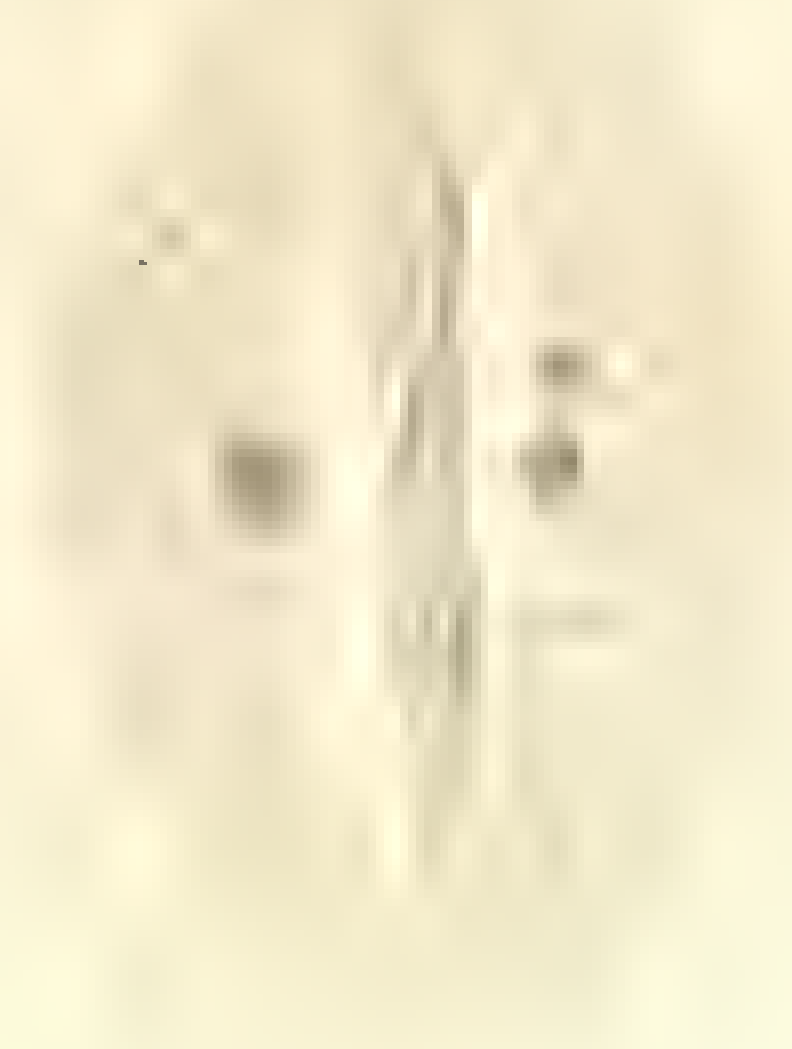


14



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left; a shrinkage in the size of the nucleus is marked in passing from *fig. 3* to *figs. 6–7* and succeeding figures.

FIG. 8–9. The linin commences to aggregate near the center of the nucleus; shrinkage continues and dissolution of the membrane proceeds.

FIG. 10. Linin threads assume spindle form; shrinkage continues and with it increase in the thickness of the layer bounding the nucleus.

FIG. 11. Well defined spindle surrounded by residue of the membrane, now a mass of substance staining densely with the orange G; chromosomes near equator and several nucleoli present.

FIG. 12. Chromosomes passing toward poles.

FIG. 13. Chromosomes at the poles.

FIG. 14. Constriction of the nuclear spindle at the equator preparatory to final separation of the daughter nuclei.

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THE MACCHIE OF THE NEAPOLITAN COAST REGION.

J. Y. BERGEN.

(*Continued from p. 362.*)

CLIMATIC ENVIRONMENT. ADAPTATIONS TO CONDITIONS.

The general character of the Neapolitan climate, with its mild moist winters and long dry summers, has been mentioned in a previous article. The irregular distribution of the mountains along the coast of the Bay of Naples and upon its islands produces considerable inequalities in the rainfall of localities not widely separated.

In Capri, during the summer in which I was engaged in studying its flora (1902), the precipitation was less than usual, 45^{mm} in May, ending on the twentieth, and then a rainless period of four months, except for a shower of 6^{mm} on September 13. During a more nearly average year (1901) the precipitation for May was 179^{mm}, June and July 56.5^{mm}, August none, and September 97.2^{mm}.

During the three hot, dry months (June, July, August) the nights are usually moderately cool. In 1902 the minimum for the three months was 10.8° C. The maximum for the same period, measured under strictly standard conditions, was 31.9° C. The average of daily maximum temperatures for June, July, and August was 26.4° C. It is noteworthy that the heat is continuous, the maximum of each day usually differing less than 2° from that of the day before or the following day. The desiccating effect of hot air upon vegetation is, of course, largely dependent upon the relative humidity of the atmosphere. During June, July, and August, 1902, the relative humidity at 3 P. M. never exceeded 81 and not infrequently fell to 30 or less; once as low as 27. The average relative humidity at 3 P. M., for the three months in question, was 55. The average velocity of the wind in summer at 3 P. M. was about 9^{km} per hour.

It should be remembered in discussing the conditions of existence of plants during hot and dry periods that they are often exposed to the full heat of the sun, and therefore to a very different temperature from the recorded maximum of a meteorological observatory. Observations on the northwestern slope of Monte Solaro, Capri, at about 350^{m} above sea level gave a temperature in the shade August 20 of 31.6° C., at 2 P. M. Burying the bulb of the thermometer a centimeter or two in the soil, in full sunshine, gave a temperature of 50.5°, and placing the bulb of the instrument on the surface of the ground and covering it with dry grass, to exclude the direct rays of the sun, gave a reading of 52.2°. Other days during the same month gave a temperature, as recorded at the neighboring observatory, over three degrees higher than that of August 20, so that the surface temperature, in sunshine, must have been at times as high as 55° C., with a relative humidity as low as 29. This extreme heat is sufficient to demand elaborate protection to prevent excessive transpiration; it approaches the temperature (50° to 60°) of desert soil at midday in summer reported by Volkens.[3] Examination near the locality above mentioned showed during early September an entire lack of sensible moisture, *i. e.*, moisture evident to the eye or the touch, to a depth of from 1 to 2^{m}.

Some data in regard to temperature and rainfall, as recorded at the Royal Observatory of Capodimonte, Naples, are given in the little table subjoined. It is noticeable that the mean of

1902	Mean value of maximum daily temperatures (° C.)	Mean values of minimum daily temperatures (° C.)	Mean value of daily humidity at 3 P. M. (per cent.)	Total rainfall (millimeters)	Means of maximum daily temperatures for thirty-five years (° C.)	Mean rainfall for thirty-five years (millimeters)
May	18.35	11.42	55.3	80.2	21.70	53.42
June	23.99	16.50	55.0	8.0	25.41	31.04
July	28.73	20.50	53.8	0.0	28.53	19.12
August	28.66	20.29	53.8	9.0	28.34	23.88

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[3] GEORGE VOLKENS, Flora der ægyptisch-arabischen Wüste 23. Berlin, 1887.

maxima of daily temperatures is a little higher, the mean daily humidity a trifle lower, and the rainfall notably more than at Capri. On the mainland in general the temperatures would run somewhat higher and the humidity lower than at Capodimonte.

The total rainfall for the year at Capodimonte (average of 35 years) is 865.5^{mm}. In an average winter there are only two days in which the temperature falls below 0° C.

The plants which constitute the macchie of the territory under discussion show their xerophytic character more by their mechanisms for the prevention of transpiration than by their provisions for absorbing water or for storing it in large quantities. The most notable succulent plants found in the Neapolitan region are two introduced species, *Agave americana* L., and *Opuntia Ficus-indica* Mill., neither of which occurs as a member of the plant societies here treated. The root systems of most of the plants which constitute macchie are extensive and in the case of many of the species examined by the writer contained more tissue than the stems. The most notably developed roots examined were those of *Daphne Gnidium*. This occurs as an undershrub, with slender clustered stems, usually less than a meter in height. In one specimen examined the average height of the stems was 70^{cm} and the total length of the tap root and its immediate branches was 490^{cm}, with a diameter at the crown of 7^{cm}. The leafy stems together weighed 190^{gm}, while the root system (not quite all secured) weighed $3{,}030^{\text{gm}}$. The roots evidently contained much water, and this accounts for the fact that the Daphne, after four months of rainless, hot weather, showed perhaps less signs of distress than any other member of the plant society to which it belonged except Thymelaea.

It has seemed to the writer best worth while to devote his attention mainly to the discussion of the various hindrances to transpiration which present themselves in the most evidently well-equipped of the xerophytic shrubs and undershrubs already enumerated. These adaptations may perhaps best be exhibited in some such table as the following:

MEANS OF PROTECTION AGAINST EXCESSIVE TRANSPIRATION.

	Leaflessness	Leaves (or cladodes) more or less vertical	Acicular or subulate leaves	Minute leaves	Leaves deciduous in summer	Leaves rolling up or withering	Leaves permanently concave, revolute or sulcate	Leaves with glossy epidermis	Leaves coriaceous	Leaves hairy or sericeous	Leaves aromatic	Leaves varnished	Stomata sunken in pits or furrows	Epidermal cells liquefied	Containing stored water or mucilage	Upper epidermis destitute of stomata
1. Ruscus aculeatus L.	×	×											×		×	
2. Asparagus acutifolius L.	×												×			
3. Pinus halepensis Mill.			×											×		
4. Erica arborea L.			×													
5. Ulex europaeus L.			×													
6. Euphorbia dendroides L					×											×
7. Euphorbia spinosa L.				×												
8. Thymelaea hirsuta Endl.		×		×			×	×	×	×					×	
9. Calycotome villosa Link.					×					×						×
10. Spartium junceum L.				×	×								×			
11. Anthyllis Barba-Jovis L.				×			×			×						×
12. Coronilla Emerus L.					×											×
13. Cistus villosus L.					×	×				×						
14. Cistus salvifolius L.					×	×				×						×
15. Cistus monspeliensis L.							×				×	×				
16. Inula viscosa Ait.						×					×	×				
17. Myrtus communis L.								×	×		×					×
18. Rosmarinus officinalis L.							×		×	×	×					×
19. Daphne Gnidium L.		×						×	×							×
20. Pistacia Lentiscus L.								×	×							×
21. Arbutus Unedo L.								×	×						×	×
22. Smilax aspera L.								×	×							×
23. Rhamnus Alaternus L.								×	×							×
24. Lonicera implexa Ait.								×	×							
25. Ceratonia Siliqua L.								×	×						×	
26. Phillyrea variabilis Timb. & Lor.									×							
27. Quercus Ilex L.									×	×				×		×
28. Quercus Aegilops L.									×	×						×
29. Quercus Cerris L.									×	×						
30. Quercus pubescens Willd.									×	×						×
31. Clematis Flammula L.										×						×
32. Cytisus spinescens Sieb. var. ramosissimus Ten.				×						×						×
33. Cytisus triflorus L'Her.										×						
34. Cytisus monspessulanus L.										×						
35. Cystisus hirsutus L.										×						
36. Rubus discolor W. & N.										×						×

The characteristics which belong to each species are checked in the horizontal line on which the name of the species occurs.

It is evident at a glance that a majority of these plants have more than one adaptation each to prevent too rapid transpiration. *Thymelaea hirsuta*, which is protected in the greatest number of ways, is notable as being equally at home on parched mountain sides and in the somewhat saline, almost waterless, sands of Mediterranean beaches, above the reach of ordinary waves. Six species are set down as deciduous in summer, but they are not all equally so. The most notable of these are *Spartium junceum* and *Euphorbia dendroides*. The former generally loses all its leaves early in the dry season and does not usually acquire new ones until the following February, while the *Euphorbia*, when in fairly good soil, retains all, or nearly all, of its immense number of leaves (much like those of *E. Cyparissias* L. of the northeastern United States, only on a larger scale). But in the scantiest soil, or when found growing in the crevices of sunny cliffs, *E. dendroides* appears in summer as a rather succulent, absolutely leafless, much-branched undershrub of a meter or less in height. The economy in transpiration, due to the leafless summer condition of the plant, may be appreciated from the results of a rough experiment. A leafy twig, cut on August 29, 8^{cm} long, bore 86 leaves, of an area varying from $9^{sq\ cm}$ each for the older leaves to about $0.25^{sq\ cm}$ each for the youngest ones. The cut end of this twig was sealed with grafting wax, the cut end of a leafless twig was similarly sealed, then both were weighed and left for 48^{hrs} freely exposed to the air and sunshine. On reweighing, the leafless twig was found to have lost 5 per cent. of its weight and the leafy one 23 per cent.

The large number of plants in these macchie which owe their tolerance of extreme drought to a glossy reflecting leaf epidermis (and usually also to the coriaceous texture of the leaves) is a noteworthy fact. Various species of the same genus are often protected against excessive transpiration in very different degrees. For instance *Quercus Ilex*, *Q. Aegilops*, *Q. Cerris*, and *Q. pubescens* constitute a series of decreasingly xerophytic character. The first has small, extremely coriaceous leaves, with a felt-like pubescence beneath; the second has larger leaves, which are very coriaceous, and beneath are stellate hairy; the third has larger leaves which are less coriaceous and only moderately pubescent, while the fourth has leaves equally coriaceous with those of *Q. Cerris*, but hardly at all pubescent except when young.

As is often the case in other plant societies, some genera of the macchie show various modes of adaptation to their conditions of life in the several species which represent them. For instance, *Euphorbia dendroides* is protected from dessication mainly by its summer-deciduous habit, while *E. spinosa* is rendered secure by the meagerness of its foliage and the spiny character of its densely clustered branches. *Cistus villosus* and *C. salvifolius* have pubescent leaves, which roll up somewhat or even wither or fall during the season of extreme drought, while the narrow, revolute-margined, somewhat aromatic, viscid leaves of *C. monspeliensis* suffer little or no change even in the driest weather.

The species numbered 20–28 in the preceding table are (with the exception of no. 24) typical members of the sclerophyll society which Schimper describes[4] as the Mediterranean *Hartlaubflora*. As broad-leaved evergreens, they form a conspicuous feature of every wooded landscape, and the dark green color and glossy surface of the leaves of such shrubs and trees as the Pistacia, the Arbutus, the Rhamnus, and the Ceratonia make them highly ornamental. The coriaceous quality of these leaves is of service, as pointed out by Beck (*op. cit.*, p. 116) in withstanding the severe lashings which they undergo from the frequent winter rain and wind storms of the Mediterranean coast, and, as suggested by Kerner in his *Oesterreich-Ungarns Pflanzenwelt* 190, in enduring occasional frosts. In this latter respect some species are not much inferior to the evergreen species of Rhododendron of the eastern United States.

It has been impossible for the writer to secure suitable laboratory facilities for the detailed study of the leaves of the trees and shrubs discussed in the present paper, at times when he could avail himself of them. Many species have been fully investigated by competent hands, but others which have not will repay thorough study. Only a few notes are here offered.

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[4] Pflanzengeographie. Jena 1898. Pp. 547–55.

Most of the evergreen sclerophyll species examined have a thick, apparently structureless cutinized layer overlying the cells of the upper epidermis. In *Rosmarinus officinalis*, *Pistacia Lentiscus*, *Smilax aspera*, and *Quercus Ilex*, this layer is especially well developed. In the species of the macchie generally the upper epidermis is destitute of stomata. Those checked as thus characterized in the table (p. 419) do not by any means exhaust the list, since the leaves of many species were not readily available to the writer for examination. *Olea europea*, *Colutea arborescens*, and *Viburnum Tinus*, occasional members of the Neapolitan macchie, are all destitute of stomata in the upper epidermis. On the other hand, *Inula viscosa* has many, but its leaves wither in the hottest weather, and they are somewhat protected by a varnish-like covering. *Spartium junceum* also possesses very small stomata in the epidermis of the upper surface of the leaf, but the leaves are few in number, small, and deciduous in summer. *Convolvulus Cneorum*, an undershrub of rare or local occurrence, has many stomata in the upper leaf surface, but these are protected by a dense layer of closely appressed long silky hairs. The case of *Thymelaea hirsuta* is particularly interesting. It has already been mentioned as an extremely xerophilous plant, and the histology of its leaves throws much light on its power to regulate transpiration. The leaves are numerous, about 5^{mm} long by 3^{mm} wide, somewhat appressed to the branchlets, with the outer surface smooth and shining, the inner surface concave and densely covered with a short, kinky, white pubescence. The branches droop, so that the outer leaf surfaces, which are morphologically the lower or distal ones, are geocentrically the upper surfaces. These contain no stomata, but the concave, pubescent inner surfaces are provided with stomata. The outer epidermis is covered with a cuticular layer, lined with hemispherical cells of a pale yellowish color, apparently containing water stored in the form of a thin mucilage. The next layer is of larger cells, which appear to contain nearly pure water. The mesophyll, which constitutes the main bulk of the leaf, is loose, with no well-differentiated layers of tissue.

Perhaps it would not be easy to sum up the characteristics of the histology of the leaves of most of the species which constitute the macchie better than by referring to a paper by W. Russell.[5] He has made a careful comparison of the structure, especially of the stems and foliage, of fifty-eight species of plants, taking specimens of each from the neighborhood of Paris and also from Carnoules, on the French Mediterranean coast. Working out the histology of these, with reference to the influence of the Mediterranean climate on structure, he has (among other differences) established the following regards in which the southern differ from the northern forms: Epidermis with larger and higher cells, with more regular contours and thicker walls; more intense lignification; increase of volume of wood and of bast; increase of thickness of leaves.

Generally speaking, these differences between Mediterranean and more northerly individuals of the same species are similar to those which distinguish the Mediterranean from more northerly species of the same genus. This is well shown by comparing, for instance, the Neapolitan species of *Smilax*, *Quercus*, *Rhamnus*, *Rubus*, *Rosa*, and *Viburnum* with those of northern Europe or the northern United States.

Naples, Italy.

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BRIEFER ARTICLES.

A MINNESOTA SPECIES OF TUBER.

(WITH THREE FIGURES)

THE Tuberaceae, which occur abundantly in Europe, have as yet been but sparingly reported from North America. In Saccardo's Sylloge[1] *Tuber macrosporum* Vittad. is reported from Pennsylvania. No authority is cited, and it has been impossible to find the original report. *Terfezia leonis* Tul., a member of the closely allied order Elaphomycetaceae, is reported by Rev. A. B. Langlois[2] from northwestern Louisiana, and has been distributed by Ellis in his *North American Fungi.*[3] Dr. R. Thaxter reports to me that *Tuber dryophilum* Tul. is common in parts of New England, and that other tuberaceous fungi occur there, though not in abundance. The only other report of the occurrence of tuberaceous fungi in North America is from California, where Harkness[4] has found a large number of species of Tuberaceae, including thirteen species of the genus Tuber, seven of which he describes as new.

In view of these facts the occurrence of a species of Tuber in the interior of the continent, and in the most northern part of the United States, is of more than ordinary interest.

On March 11, 1903, specimens of a species of Tuber were collected by Mr. H. L. Lyon in the vicinity of Minneapolis, Minn. The locality where the fungi were found is a steep bank with southern exposure. The soil is a stiff calcareous clay, covered with a shallow layer of leafmold. At the time of collection a week of warm weather had melted the winter's snow and thawed the soil to the depth of several inches, but the clay subsoil was still frozen hard, and the surface soil had been soft for only a very few days.

The fungi were found in the leaf-mold about the base of a small group of basswood trees (*Tilia americana* L.). A further collection was made two days later from the same locality, and in all about thirty specimens of the fungus were obtained. Search has been made under other trees in the same vicinity and elsewhere, but as yet no further localities have been found.

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[1] SACCARDO, P. A., Sylloge Fungorum 8: 887.

[2] Journal of Mycology 3: 10. 1887.

[3] ELLIS, J. B., and EVERHART, B. M., North American Fungi, second series, no. 1782.

[4] HARKNESS, H. W., California hypogaeous fungi. Proc. Cali. Acad. Sci. 8 Jy. 1899.

All the fungi collected were in a mature condition. There had hardly been time for their development this spring, though such forms as *Saccoscypha coccinea* Jacq. had already made their appearance. It seems probable that the ascomata of the truffle are formed in the late autumn, and lie over the winter in a practically mature state. They probably break down early in the spring. Of a number which were collected and placed in earth out of doors, the greater part are yet (March 26) in a good state of preservation, but though there has been very little warm weather since the date of their collection, and the ground has been covered with snow for a portion of the time, several of them are beginning to show signs of disintegration.

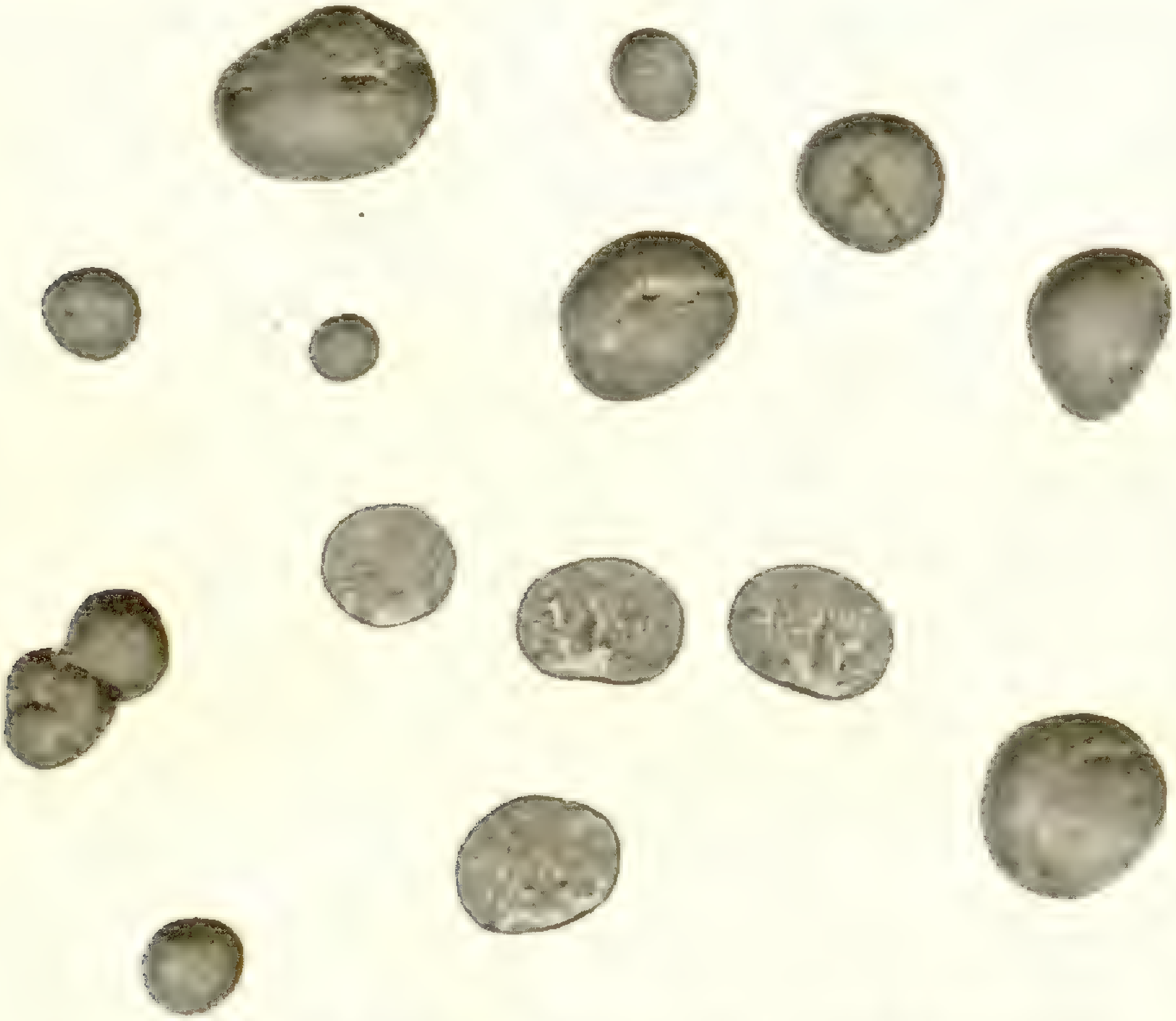

FIG. 1.—Group of the fungi, natural size. From a photograph.

The fungi vary from 0.5–2^{cm} in diameter (*fig. 1*). The smaller ones are almost spherical, the larger of a somewhat irregular elliptical form. In one case two have evidently grown together during their formation, producing a peculiar dumb-bell shaped body.

Along one side of the fungus runs an irregular scar-like groove which extends from one fourth to over one half way around the fruit body. In a few specimens this scar is interrupted, and in some it forks or branches somewhat, but it is usually unbranched and continuous. As the fungi lie in their natural position in the soil, this scar maintains no fixed position in relation to the surface of the ground, but is turned in various directions. The surface of the fungus is smooth, slightly pruinose, becoming finally very slightly and minutely areolate. The color is a light chestnut brown, which becomes blackish in spots as the gleba begins to break down. The fungi have a peculiar heavy but not disagreeable odor resembling that of "malted milk."

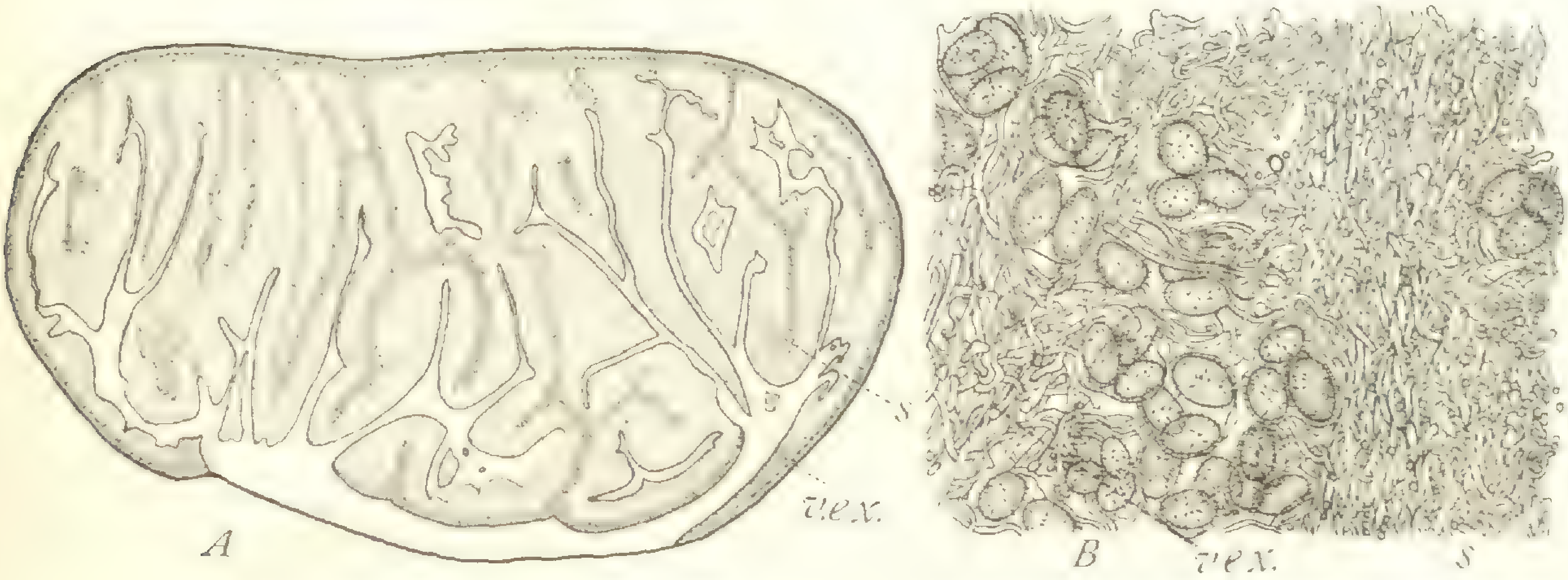

Fig. 2.—*A*, diagram of a longitudinal section passing through the scar, × 8; *B* detail of a portion of the gleba, × 330. *s*, septa; *v. ex.*, venae externae.

The peridium is rather thin, tough, and cartilaginous, composed of an outer opaque layer and an inner translucent layer. The outer layer of the peridium consists of hyphae having a general radial arrangement, but so closely intertwined as to have almost the appearance of pseudo-parenchyma. Within this is a thin layer of more loosely interwoven hyphae, running for the most part parallel to the surface of the fungus, and within this again a tissue composed of closely packed strands of hyphae running in many directions but all having a general concentric arrangement. The middle layer seen in microscopic preparations is not visible to the naked eye, and may be barely distinguished under the hand lens as a faint line between the outer and the inner peridium.

The gleba is violaceous brown, marbled with numerous veins of two kinds. The venae internae, or septa (*s*, *fig. 2*) are extensions of the inner layer of the peridium into the interior of the fungus. The removal of the outer layer of the peridium exposes the origin of these septa as a network of numerous anastomosing lines covering all parts of the fungus except that immediately under the scar. In a section of the fungus the septa appear as labyrinthiform anastomosing veins of a dark translucent gray color, appearing in freshly cut specimens darker than the hymenial layer. In specimens preserved in alcohol they become white and are difficult to distinguish from the venae externae.

The venae externae (*v. ex., fig. 2*) appear in a section of the fungus as branching veins of a pure white color, and of a cottony aspect under the hand lens. They alternate with the darker septa, ending blindly toward the periphery, but all communicate with a mass of similar tissue which underlies the scar, and through it communicate with the exterior. This mass of tissue is in places lined with a layer similar to the inner peridial layer, but in other places it abuts directly upon the hymenial tissue. In cases in which the scar is interrupted, the mass of underlying tissue is likewise interrupted, and the venae externae accordingly form more than one group.

The hymenial layer is embraced between these two types of veins. It is of a fleshy but somewhat granular texture, and of a violaceous brown color.

The septa are composed of densely interwoven hyphae having for the most part a radial course, though strands of hyphae running in other directions are not uncommon (*s, fig. 2, B*). The venae externae (*v. ex., fig. 2, B*) consist of more loosely intertwined hyphae. The hymenial layer consists of closely packed asci interspersed with numerous hyphae, and forming no definite palisade layer. The hyphae of the venae externae and of the gleba are very large (4–10μ in diameter), septate, and sparingly branched. The asci are difficult to see clearly in a section, but may be easily seen in macerated material. They are 1-5-spored, but nearly all of them are 4-spored. The ascus is irregularly elliptical, averaging $45 \times 70\mu$ (p. sp.) and usually is furnished with a long pedicel. *Fig. 3, A* shows the most common form of ascus, but irregular asci like that shown in *fig. 3, B* and *C* are not uncommon.

The spores are large, elliptical, acutely echinulate, and of a slightly violaceous brown color. Spores occurring in 4-spored asci measure $15–25 \times 25–38\mu$, averaging $22 \times 35\mu$. The spores from one-and two-spored asci are larger, in the former case reaching $31 \times 48\mu$.

As will be seen by this description the fungus belongs to the genus *Tuber* (subgenus *Aschion*), and approaches very close to *Tuber rufum* Pico, and to *T. nitidum* Vittad. in general characteristics and microscopic structure. It is less roughened externally than the typical form of *T. rufum*, and is distinguished from both of the species named by the color of the gleba and spores, by the more conspicuous veins, by the more densely crowded asci, by the slightly larger size and more elongated form of the spores, and apparently also by the greater extent of the scar-like external opening of the venae externae.

Tuber Lyoni n. sp.—Ascomata globose or irregularly elliptical, $0.5–2^{cm}$ in diameter, having a distinct scar-like groove along one side, smooth, light chestnut-brown, becoming finally very minutely areolate and blackish. Peridium not thick, cartilaginous. Gleba violaceous brown, fleshy but somewhat granular. Septa arising from the peridium, numerous, anastomosing, labyrinthiform, dark translucent. Venae externae white, conspicuous, opening externally throughout the length of the groove. Asci pedicellate, 1–5- mostly 4-spored. Spores elliptical, acutely echinulate, 15–31 × 25–48 μ. Type specimens are deposited in the Herbarium of the University of Minnesota.

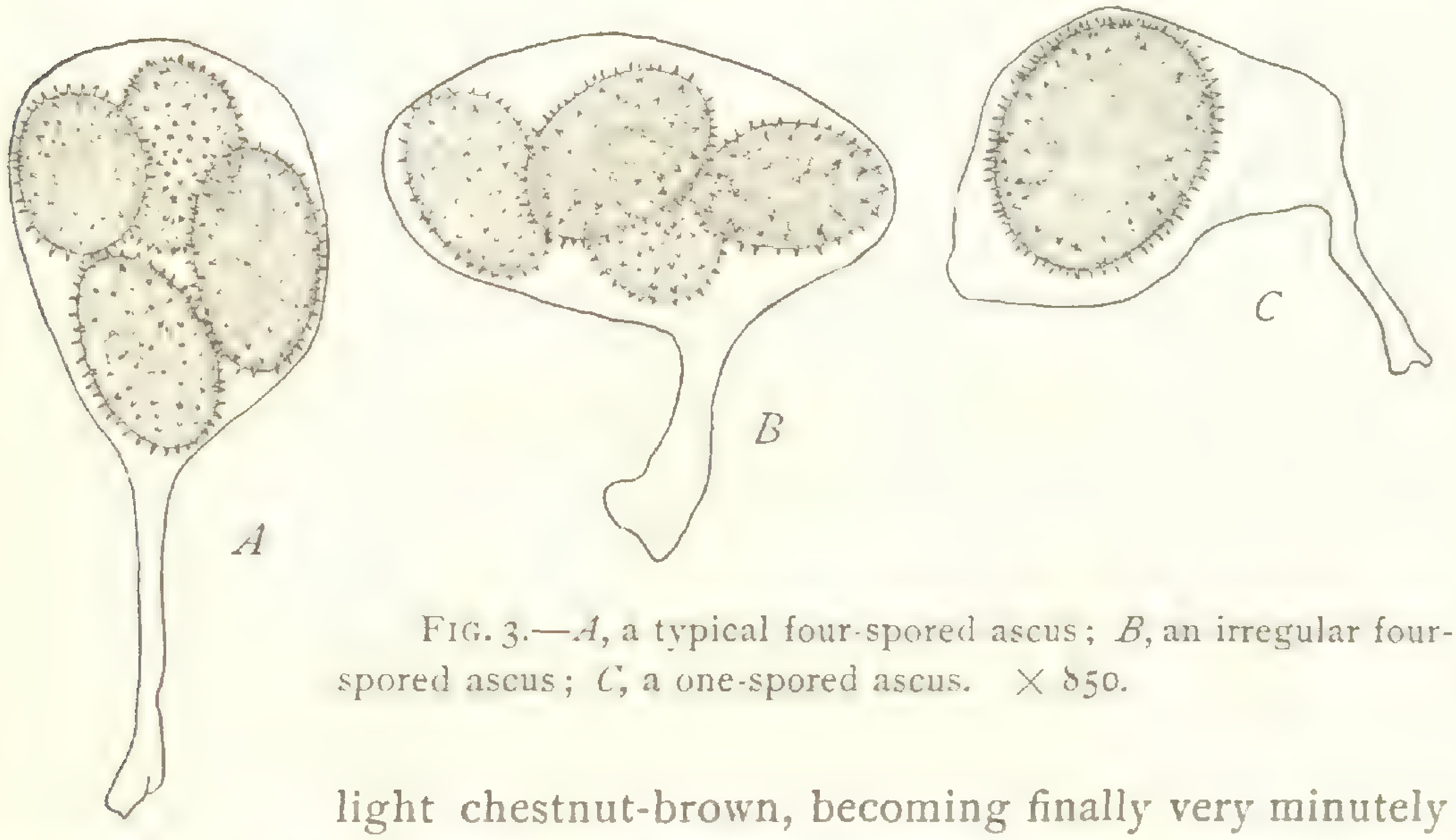

FIG. 3.—*A*, a typical four-spored ascus; *B*, an irregular four-spored ascus; *C*, a one-spored ascus. × 850.

The occurrence of this form in Minnesota suggests that it is very possible that this and other species of tuberaceous fungi are not uncommon in the interior of North America. The conditions of their growth render their discovery almost entirely a matter of accident, and in the case of *Tuber Lyoni* the peculiar season at which it occurs may further account for the fact that it has not been hitherto discovered.—FRED K. BUTTERS, *University of Minnesota*.

A NEW BOTANICAL RESEARCH LABORATORY IN THE TROPICS.

In the year 1901 I paid a visit to the colony of Surinam (Dutch Guiana), and as a result of this voyage a scientific laboratory will be opened this year in Paramaribo. A botanist and a chemist will be connected with this laboratory, one of them with the title "agricultural inspector for the Dutch West-Indian colonies." I wish to draw the attention of American botanists to this laboratory, because it will contain a room, 9 by 4.5 meters, where foreign naturalists will have the opportunity for research work.

It is needless to argue here on the advantages of a botanical research laboratory in the tropics; the experience of the botanical garden at Buitenzorg speaks for itself. But for many scientific men in the States Buitenzorg is too far away, and on the other hand there are several problems which can be studied only in tropical America.

For this reason I should like to give here a few more particulars about this laboratory. It will be built in the small experiment garden now existing, which is in great part uncultivated, with an interesting secondary forest. In the vicinity may be found tidal and swamp forests. The large rivers of Surinam are the means of communication with the interior; there is a service of regular steamers on some of them. In the neighborhood of the coast are the European cacao and sugar estates. Bordering the rear of these estates are primeval forests, which cover a great area of the colony; they are perhaps more luxuriant than any in the world. Moreover, the botanist will find large and interesting savannas, and he who can go farther into the interior (the easiest way will be to visit some of the gold fields) may gather many Podostemaceae in the rapids of the upper part of the rivers. Epiphytes (among these especially Bromeliaceae, Orchidaceae, Cactaceae, Ficus), lianes, cauliflorous trees, myrmecophilous trees, Loranthaceae and other parasites—in one word, all the many ecological characteristics of the tropics with their damp climate—may be seen in their highest degree of development here.

Though malarial fever may occur in the interior of Surinam, Paramaribo is almost free from it, and generally speaking it is a healthy town. Yellow fever is almost extinct; since 1867 there has been only one small epidemic, in 1902. From my own experience I feel quite certain that naturalists will be kindly received by the inhabitants and will get a great deal of help from private persons as well as from officials.

Hotels in Paramaribo cannot be said to be very good, though they are not expensive; the average price per day is fl. 5 ($2). In the interior there do not exist hotels or boarding-houses; whoever cannot be the guest of a planter or other European living in the interior will have to carry with him a hammock, tinned food, and other necessities. If we estimate for traveling and other smaller expenses $200, for clothing $100–$150, a four-months stay would cost about $540–$600 plus the steamship fares. There are several direct lines from the United States to Barbados, whence every fortnight a steamer of the Royal Mail Steampacket Company sails for Demerara and Paramaribo in about four or five days. The Dutch mail steamers of the Koninklijke West-Indische Maildienst (Royal Dutch West-Indian Mail Service) sail twice a month from New York via Port-au-Prince, Aux Cayes, Jacmel, Curaçao, Puerto Cabello, La Guayra, Guanta, Cumaná, Carupano, Trinidad, and Demerara to Paramaribo, whence they proceed to Amsterdam. A first-class ticket from New York to Paramaribo costs $100; a return ticket, available for a year, $170. But the company is willing to give a reduction of 15 per cent. on this tariff to every naturalist who goes to Surinam with the aim of studying in the laboratory in Paramaribo. In order to get this reduction one has to make an application (with documents to prove this intention) to the agents of the company at New York (Kunhardt & Co.).

The average temperature at Paramaribo is 27° C. (max. 30–33°, min. 20–22° C.). The big rainy season lasts from the middle of April to the end of February; the dry seasons very often are not so very dry; the total amount of the rainfall is about 2,500$^{\text{mm}}$ yearly. The flowering times are about August, September, October, and from January till April. Whoever intends to make a stay in the new laboratory will have to apply to the agricultural inspector in Paramaribo, whose appointment will be made shortly and will be announced in the botanical journals; moreover, I am willing to give any further information. —F. A. F. C. WENT, *University of Utrecht, Holland.*

NEW OR LITTLE-KNOWN WOODY PLANTS.

Crataegus hystricina, n. sp.—A small irregular shrub 9–15$^{\text{dm}}$ high, with several stems from the same root. Bark on the slender stems rough, dark gray, that on the branches smooth and lighter. Twigs stout, red-brown, glabrous, armed with brown-purple thorns 4–6$^{\text{cm}}$ long. Leaves ovate or suborbicular, abruptly acute at apex, rounded or acute at base, glabrous, with five or six pairs of prominent veins, sharply doubly serrate except at the base; petiole 2 cm long, winged above by the decurrent blade. Flowers appear the first week in June, about 20 mm wide, in ample wide-spreading glabrate or sparingly pubescent corymbs; calyx tube cup-shaped, glabrous, the narrow triangular glabrate acute lobes twice or thrice the length of the tube, deeply glandular serrate, reflexed after anthesis; stamens large, 10, anthers pale violet with darker edges; styles 2–3. Fruit in large drooping clusters, bright scarlet, globose, about 1 cm in diameter, capped by the long spreading or reflexed calyx lobes, ripening in September; seeds generally 3, lateral faces grooved.

Crataegus hystricina has been found only along the rocky bank of the Housatonic river in Southern Connecticut, where it has been collected and studied by *Dr. E. H. Eames.* It is evidently closely related to *C. succulenta*, from which it is well separated by the larger foliage, larger flowers, fewer stamens and different habit.

Amelanchier obovalis, n. sp. *Mespilus Canadensis obovalis* Michx. Fl. 1:291; *Crataegus Canadensis obovalis* Sarg. Silva 4:128 in part.—A shrub 9–15 dm high, with numerous erect virgate shoots, or a small tree with short ascending branches attaining a maximum height of about 4.5 m. Leaves elliptic, rounded at both ends, 2–3 cm wide, 3–5 cm long, on unfolding densely tomentose beneath, at length nearly glabrous but pale, finely serrulate or nearly entire; petioles short, pubescent. Flowers appearing from the first to the middle of April when the leaves are less than half grown, in short (3–5 cm long) 5–9-flowered, strict, compact, pubescent racemes; pedicels 2–9 mm long at time of flowering, elongate in fruit, especially the lower ones, which become 2–3 cm long; petals oblong, 6–8 mm long; calyx broadly cup-shaped, the lobes erect or ascending, short and broad, pubescent, greatly enlarging after anthesis and becoming glabrate. Fruit when ripe in June red-purple, subglobose, 7–9 mm in diameter.

This plant is not uncommon along the edges of swamps on loose soils from Smithfield, N. C., southward along the coast to Augusta, Ga., and according to Sargent (Silva 4:128 seq.) to Mobile, Ala. In leaf form and inflorescence, it is most closely related to *A. spicata* (Lam.) Dec., from which, however, it is well separated.

Amelanchier obovalis was found by the elder Michaux on the coast of Carolina. Torrey later transferred the name to *A. botryapium* and was followed by Sargent, who, while having knowledge of the existence and distribution of the coast plant, confused it with *A. botryapium* and associated both plants under the same name as a variety of *A. canadensis* med.

Crataegus Wilkinsoni, n. sp.—A tree 3–5^{m} high with long horizontal branches forming a flattened crown, trunk armed with numerous long, often compound, thorns. Bark on the scaly trunk gray, that of the branches smoother and lighter. Twigs glabrous, slender, olive or russet, armed with many stout 4–6^{cm} long dark gray thorns. Leaves spatulate, 5–9^{cm} long including the very short petiole, 2–3^{cm} wide, acute or obtuse at apex, gradually tapering into the short grooved winged petiole, glabrous, dark green above, much paler beneath, thin for the group, the 3–5 pairs of prominent veins impressed above, obtusely serrate above the middle, seldom lobed. Flowers about 14^{mm} wide, in large compound many-flowered glabrous corymbs, appearing the first week of June; calyx obconic, glabrous, the narrow entire lobes reflexed after anthesis; stamens about 10, anthers pink; styles 2–3. Fruit in large compound clusters on drooping pedicels, oblong, 16–18^{mm} long, full and rounded at the ends, dull red, capped by the reflexed calyx lobes, ripening early in October, persistent until late in winter; flesh firm, bitterish; seeds generally 2, sometimes 3, deeply grooved on the rounded back.

The species above proposed was collected in both flower and fruit at Mansfield, O., by *E. Wilkinson*, who has permitted me to associate his name with the plant; collected also in fruit by *W. W. Ashe.* It differs from the typical cockspur thorn in the longer, thinner, and more pointed leaves, and deeply impressed veins. It is more closely related to *C. Canybi* Sarg. (Bot. Gaz. 31:3. 1901) which it much resembles in the shape of the leaves, and the impressed veins, and from which it is separated by having longer, stouter thorns, thicker foliage, smaller fruit, and fewer differently colored anthers.

Crataegus habilis, n. sp.—A tree 4–6^{m} high with numerous spreading and ascending branches forming an oval crown. Trunk sparingly armed, its bark scaly, trunk dark gray or brown, that of the branches smoother and lighter. Twigs ascending, glabrous, thick, soft, olivaceous or chestnut-brown, sparingly armed with stout chestnut thorns 3–4^{cm} long. Leaves thin but firm, dark green above, paler beneath, the blades broadly oval, 4–5^{cm} long, 3–4^{cm} wide, abruptly acute at apex, rounded or truncate at base, with 4–6 pairs of shallow notches, sharply but finely serrate, glabrous below on unfolding, pubescent above with short hairs, soon glabrous, fading to lemon yellow and falling late in September or early in October; petiole about 2^{cm} long, slender, nearly terete, grooved above, at first pubescent, soon glabrous. Flowers 16–20^{mm} wide, borne in small 3–4^{cm} wide, nearly simple pubescent cymes, cup-shaped, appearing the second week in May when the leaves are about half grown; calyx cup-shaped, nearly glabrous, the large triangular glabrate deeply glandular serrate lobes spreading after anthesis; stamens large, generally 5, sometimes 5 to 8 or 10; anthers rose-purple; styles 4–5. Fruit in small 4–6 fruited somewhat compound clusters, on spreading or nodding pedicels, dull scarlet with orange spots at apex, globose, 14–17^{mm} thick, concave at base, sometimes capped by the large spreading or ascending generally entire lobes, ripening early in September and falling soon after; flesh thick, yellow, juicy; seeds generally 4, somewhat grooved on the rounded back, the lateral faces plane.

The type material was collected at Mansfield, O., by *E. Wilkinson* and *W. W. Ashe* in 1901 and 1902, growing on sunny hillsides with oaks and hickories. *Crataegus habilis* is separated from the other FLABELLATAE having 5 to 10 stamens by the subglobose fruit, small deeply lobed foliage, and small short pediceled corymbs.

Crataegus pentasperma, n. sp.—A tree 4–6^{m} high with an oval crown and long spreading or pendent branches. Trunk armed with numerous thorns 4–6^{cm} long, its bark nearly black, broken by shallow furrows or into small scales. Twigs slender, geniculate, at first pubescent, at length glabrate, armed with numerous thorns 3–5^{cm} long. Leaves firm, bright green and glabrous above, pubescent beneath when young, at length nearly glabrous, except in the axils of the primary veins, the blades 2.5–4^{cm} long, 1–2^{cm} wide, obovate or spatulate, obtusely glandular serrate, rounded or acute at apex, often 3–5-notched above the middle, cuneate at the entire base, 1–3 pairs of ascending primary veins; petiole slender, 1–2^{cm} long, pubescent and roughened with several pairs of dark glands (or the leaves on vigorous shoots nearly orbicular and deeply lobed, with persistent foliaceous stipules). Flowers small, in 5–10-flowered simple or somewhat compound villose corymbs, appearing in the vicinity of Franklin, N. C., the last of May; stamens small, 20; styles 5. Fruit in loose compound or simple clusters, on pendent pubescent pedicels, pyriform, longer than thick, 11–14^{mm} long, green or green mottled with orange and red, occasionally capped by the stalked reflexed lanceolate villose glandular serrate calyx lobes; flesh thin, very firm and white; cavity small; seeds 5, 6^{mm} long, smooth or nearly so in the back and faces, attenuate at base. The fruit ripens late in October and falls with the leaves or soon after.

Crataegus pentasperma is separated from the other GLANDULOSAE with 20 stamens, pyriform fruit, and pubescent inflorescence, by the larger, often compound cymes, and 5-seeded green fruit. The type material is from near Franklin, Macon county, N. C.—W. W. ASHE, *Raleigh, N. C.*

CURRENT LITERATURE.

BOOK REVIEWS.

Bacteria.

THE FIRST edition of Fischer's lectures appeared in 1897, and was described by its author as an introduction to general bacteriology, "an endeavor to survey and group into a whole the salient features of the science from the larger biological standpoint." The second edition,° just from the press, retains the plan of the earlier volume, although the book has swelled to double its original size, with many additional details and illustrations. The earlier chapters, those on morphology, are among the most valuable, although the author is inclined to believe that the majority of cell variations are the result of degenerative processes, *i.e.*, are involution-forms. In this view he differs from many students who have given special names to the branching forms seen in *B. tuberculosis* and *B. diphtheriae*. In his chapter on "Die Bakterienzelle als osmotisches System," Fischer calls attention to several points in which he departs from his earlier views published in 1900, particularly his explanation of "plasmoptyse"; these changes are based upon new experiments, to be more fully discussed by him in a future publication. It is interesting to note that, in striking contrast to the "immunity"-burdened bacteriological literature of the past two years, this volume devotes nine chapters, or 117 pages, to the carbon and nitrogen cycles, while immunity, vaccination, and serum therapy are disposed of in one chapter of 11 pages. Toward this subject the author seems unsympathetic, and even suspicious; but for a student of morphological, systematic, or agricultural bacteriology the book has much to offer.—MARY HEFFERAN.

Principles of variation.

IN this book Dr. Vernon has assembled with no little skill many important data on the subject of variation and thus supplied a compendium[1] that admirably supplements Darwin's work on *The variation of animals and plants under domestication*.

The subject-matter is arranged under three main parts, viz.: I, The facts of variation; II, The causes of variation; and III, Variation in relation to evolution. In the first part we naturally expect a summary of the results of

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FISCHER, ALFRED, Vorlesungen über Bakterien. 2d edition. pp. x + 374. *figs. 69.* Jena: Gustav Fischer. 1903.

[1] VERNON, H. M., Variation in animals and plants. 8vo. pp. 415. New York: Henry Holt & Co., 1903.

biometry and we are not disappointed. However, the author has, wisely enough, avoided an extensive treatment of statistical methods. In the second part, blastogenic variation and those due to the conditions of life are treated in several chapters. In part III, natural selection and adaptive variations are discussed.

The work contrasts favorably with much that has been written on variation and evolution in a semi-popular way, in that the author retains a firm hold on ascertained fact. There is little special pleading in the book, and large generalizations are sparingly attempted; results are impartially presented and their obvious import expressed. On the other hand, the author lacks something of that vigor and enthusiasm that one finds in the champion of a cause; and occasionally there is a lack of that critical and unifying spirit that accompanies complete assimilation of the subject. For example, after reviewing Weldon's paper of 1892, our author approves Weldon's conclusion, based on shrimps, that correlation between two organs is "practically constant" for different localities. On the next page he mentions Pearson's general dissent from this view, without coming to any decision, while nothing is said of Dr. Lee's paper (1901) where the correlation-coefficient between length and height of head is given, for the Ainos as 0.50 and for the German as 0.10, showing an entire absence of constancy.

On the other hand, the treatment of certain subjects is very good. The imperfect fertility of dissimilar races when crossed is well worked out; new data concerning identical twins are given; the theory of regression is clearly explained and many facts quoted as to the effect of external conditions. In discussing adaptation, the author accepts self-adaptation as a factor subsidiary to natural selection. The degeneration of disused organs he finds difficult to account for. He should remember that all "degeneration" is not due to disuse; and that animals with "degenerate" organs, however arisen, can still be adapted if they get into situations where these organs are of no use.—C. B. DAVENPORT.

Two elementary texts.

BOTANICAL texts for the secondary schools multiply apace. Professor Stevens, of the University of Kansas, has published an *Introduction to botany*, which has many good features to commend it.[2] It is an attempt to combine the instruction of the laboratory handbook and the necessary information of the text-book. To secure the proper relations of laboratory work and reading he has introduced the laboratory directions before the discussion of the topic to which they relate. These directions are in the main clear and concise, and the work for which they provide well chosen. A particularly commendable feature is that the experiments in plant physiology are not only

[2] STEVENS, WILLIAM CHASE, Introduction to botany, pp. x + 436, *figs. 340*. Boston: D. C. Heath & Company, 1902.

well selected, but are intermixed with the work on anatomy to which they are related.

Some chapters and sections will doubtless prove very puzzling to beginners, especially those which treat of such difficult subjects as alternation of generations, heterospory, and the fertilization of the egg in angiosperms. The extreme condensation and briefness of treatment will almost defeat the purpose of the author, and we fear will cause these subjects, which ought to be made plain, to be looked upon still as beyond the reach of elementary students. The book is notable for its excellent diagrams, and on the whole is likely to prove its value by use.

Mr. E. F. Andrews,[3] of the Washington, Ga., high school, calls his book *Botany all the year round*, in itself a taking title. In the body of the book he provides ample work to occupy the students through the winter as well as the summer. Each section is preceded by a list of material needed for its study. In connection with the reading matter directions are given for the use of this material, and at the close of the section the student is confronted with a number of "practical questions." The material for study consists chiefly of the flowering plants, only one chapter (of less than forty pages) being devoted to seedless plants and one (of thirteen pages) to ecology. The rest of the book is chiefly concerned with morphology and physiology, the former strongly tinged with the formal morphology of the older school, while the latter is not always accurate, and occasionally distinctly bad. In this part also one finds a good deal of ecology, and the student will likely be confused as to the scope of ecology by the existence of a separate chapter with this label. The practical questions are mostly well calculated to set the student to thinking, but too often they are impossible for him to answer with the data at hand. This tempts him to guess and reason *a priori*, which is directly contrary to the training sought by science work. Not infrequently the author suggests an answer by referring the student to some preceding paragraph, and so cases could easily be cited to show that the asker could not answer his own questions rightly. The book gives one the impression that the author has some familiarity with modern botany, but that he has not yet thoroughly assimilated the facts which he knows. Though the book has much to commend it, it cannot compare in real value with Stevens's and several others which could be named.—C. R. B.

MINOR NOTICES.

MR. A. S. HITCHCOCK,[4] assistant agrostologist of the U. S. Department of Agriculture, has published a monograph of the ten North American species of the genus Leptochloa. No new species are described, and some forms kept separate by other authors have been united on the principle that when such forms are connected by numerous intergrading specimens they are to be considered as the same species, although typical specimens of the extreme forms may be easily distinguished.—C. R. B.

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[3] ANDREWS, E. F., Botany all the year round, pp. 302, *figs. 513*. New York: American Book Company. 1903.

[4] HITCHCOCK, A. S., North American Species of Leptochloa. U. S. Dept. of Agric., Bureau of Plant Industry. Bull. 33. pp. 24. *pls. 61*. 1903.

A CRITICAL REVISION of the genus Eucalyptus has been undertaken by Mr. J. H. Maiden,[5] the government botanist of New South Wales and director of the Botanic Gardens, Sydney. Part I of this publication has just appeared, containing in the preface a discussion of the variations in the genus, and a list of doubtful species referred to it and such species excluded from the genus, and a bibliography. The remainder of the part is devoted to a description of *Eucalyptus pilularis:* its synonymy, range, and affinities. Of the four plates two are given to the typical form of the species, another to the variety Muelleriana, and one to the illustration of fruits showing variation in the species.

NOTES FOR STUDENTS.

PROFESSOR BOWER[6] has announced the discovery of a sporophyll of *Lycopodium rigidum* bearing two sporangia side by side. The great rarity of this phenomenon emphasizes the remarkable constancy of the solitary sporangium among the true Lycopodiales.—J. M. C.

MOLISCH contends[7] that the buoyancy of the Cyanophyceae of the plankton does not depend upon gas vacuoles, and that the bodies which were so interpreted by von Strodtmann and Klebahn cannot possibly be gaseous. He was not able to determine whether they were fluid or solid, but inclines to the belief that they are viscous.—C. R. B.

HOLM[8] has used a study of *Carex fusca* and *Carex bipartita* as an occasion for severely criticising what he calls "type-species botany." He shows that the superficial determination of herbarium specimens reputed to be the type material of the older taxonomists may be very far from reaching reliable results. He says that such research should include a good deal more, such as a large amount of literary research, a study of the author's method of describing and of citing, the history of the herbarium since it left his hands, etc.—J. M. C.

[5] MAIDEN, J. H., A critical revision of the genus Eucalyptus. pp. 47. *pls. 4.* Published by Authority of the Government of the state of New South Wales. Sydney: W. A. Gullick. 1903. 2 shillings sixpence.

[6] BOWER, F. O., Note on abnormal plurality of sporangia in *Lycopodium rigidum* Gmel. Ann. Botany **17**: 278–280. 1903.

[7] MOLISCH, HANS, Die sogenannten Gasvacuolen und das Schweben gewissen Phycochromaceen. Bot. Zeit. **61**^{1}: 47–58. *figs. 4.* 16 Mar. 1903.

[8] HOLM, THEO., Studies in the Cyperaceae. XVIII. On *Carex fusca* and *Carex bipartita* All. Am. Jour. Sci. **15**: 145–152. 1903.

THE CYCADOFILICES, generally recognized as a group intermediate between ferns and cycads, have been known only by their habit and anatomical structure. The discovery of seeds belonging, in all probability, to Lyginodendron[9] lends strong support to the view that the Cycadofilices form the connecting link between ferns and cycads. Botanists must be prepared to find that many of the plants now classed under Cycadofilices possessed seeds and that many of the "fern fronds" of paleobotanists belong to spermatophytes.—CHARLES J. CHAMBERLAIN.

DARWIN AND PERTZ have confirmed their previous results in establishing artificial rhythm in plants[10] through subjecting them to periodically reversed stimulation by means of the intermittent clinostat. Both heliotropic and geotropic stimuli were used, the experiments with light being most successful. Rythmic curvatures were induced for an hour or more in *Phalaris canariensis* by 15-minute reversals of stimulation; the clinostat was then stopped, but the periodic response continued, showing one or two reversals of bending. Alternate unequal stimuli induced persistent unequal curvature.—C. R. B.

THE DEVELOPMENT of lateral members of *Linaria spuria* has been studied by Vöchting.[11] This plant is especially suitable for testing Schwendener's "contact theory," viz., that young organs are laid down in contact with the older, because in *L. spuria* the leaves are in whorls, while the flowers are arranged spirally. Vöchting bases his inferences on the transition region of the stem, and on the anomalies presented by the flowers. He comes to the same conclusion as in an earlier paper on Cactaceae, that the contact theory alone will not account for the position of lateral organs, and falls back on "inner causes" as an explanation of the phenomena observed.—M. A. CHRYSLER.

BLACKMAN[12] has shown that the behavior of germinating teleutospores of Uromyces, Puccinia, and Phragmidium depends upon the amount of water in which the spores are sown. With a thick layer of water, the germ-tube grows until it has exhausted the material of the spore, and then dies, no sporidia being produced. But if the water layer is sufficiently thin for the tube to reach the air before its growth ceases, it immediately produces sporidia in the usual way. When the teleutospores are germinated in moist air the sporidia are formed almost immediately "and the promycelium consists of little or nothing more than the characteristic four cells." This phenomenon is probably quite general among the Uredineae, but the sporidia of Ustilago are freely formed under water.—BURTON E. LIVINGSTON.

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[9] OLIVER, F. W., and SCOTT, D. H., On Lagenostoma Lomaxi, the seed of Lyginodendron. Read before Roy. Soc. London, May 7, 1903.

[10] DARWIN AND PERTZ, On the artificial production of rhythm in plants, with a note on the position of maximum heliotropic stimulation. Annals of Botany **17**: 93–100. 1903. See also *ibid.* **6**: 245. 1892.

[11] VÖCHTING, HERMANN, Ueber den Sprosscheitel der *Linaria spuria*. Jahrb. Wiss. Bot. **38**: 83–118. *pls. 2–3.* 1902.

[12] BLACKMAN, V. H., On the conditions of teleutospore germination and of sporidia formation in the Uredineae. New Phytologist **2**: 10–14. *pl. 1.* 1903.

C. K. SCHNEIDER has recently published an extended account of the native and introduced woody plants of middle Europe in their winter condition.[11] The work was done mostly at Vienna in the Botanic Garden and Hofmuseum, and is preparatory to an extended description of the woody plants of middle Europe. The first sixty-three pages are devoted to a general discussion and contain numerous cuts from photographs, illustrating habit, bark, and method of branching. The second part is a synoptical arrangement of the species, the classification being based upon characters of the buds and twigs. The species are excellently illustrated with line drawings, showing the external characters, and also by a diagrammatic cross-section. It is the most extensive work of this kind we have seen.—A. S. HITCHCOCK.

NEW OBSERVATIONS bearing upon the rôle of water in plants are made by Kurzwelly,[12] who has tested the power to resist poisons which is exhibited by various plant structures, mainly resting forms such as spores, seeds, etc. He finds that resisting power increases as the cells become drier, and that the less the water in the poison used, the longer can the cells withstand it. Thus, antiseptics are less effective in absolute alcohol than in water. This seems to be due to the inability of the solvent to penetrate the protective coverings. Gaseous poisons are more effective than those dissolved in other media than water. We may draw two general conclusions from these results: first, in most cases in order that penetration may occur, water must be present in seed-coats, etc.; and, secondly, the less water there is in the protoplasm, the less susceptible is it to the action of poisons.—BURTON E. LIVINGSTON.

MOLISCH[13] reports as a new discovery the presence of amoebae in Volvox. He has evidently overlooked the work of Hicks, published in 1860, in which a very complete account of "amoeboid bodies" in Volvox is given. According to Molisch the amoeba attacks the coenobium from without by thrusting in a pseudopodium. The number of amoebae varies from ten to thirty in each coenobium. He could not determine whether all the amoebae entered from without. As they were found in the colonies only late in November, Molisch concludes that as the vegetative period nears an end the Volvox cells become less resistant to attacks of the parasite. The account given by Hicks differs from that of Molisch only in interpretation. Hicks did not believe that amoeba could successfully attack a living cell, and as he found for each amoeba present a cell of the coenobium absent and the amoeba usually occupying the place of the missing cell, he concluded that the cell was transformed into an amoeba. A careful examination of the literature of a subject often changes a discovery into a confirmatory account.—W. J. G. LAND.

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[13] Dendrologische Winterstudien. Jena: Gustav Fischer, 1903. pp. viii + 290. figs. 224.

[14] KURZWELLY, WALTHER, Ueber die Widerstandsfähigkeit trockener pflanzlicher Organismen gegen giftige Stoffe. Jahrb. Wiss. Bot. **38**: 291–341. 1902.

[15] MOLISCH, HANS, Amoeben als Parasiten in Volvox. Ber. Deutsch. Bot. Gesell. **21**: 20–23. *pls. 3.* 1903.

BENECKE publishes the following results of experiments on brood-buds of *Lunularia cruciata*.[16] Chemical stimulation is necessary for normal development; no variations of temperature or light will produce normal thalli or rhizoids in pure water; the small amount of mineral water dissolved from certain kinds of glass is sufficient, however. In such very weak solutions light is necessary for the development of rhizoids; one per cent. solutions of certain salts produce them either in light or darkness. Complete nutrient solutions produce large thalli and short rhizoids; lack of nitrates the reverse; lack of phosphates intermediate; lack of potassium a general retardation; lack of calcium stunting, especially of rhizoids; magnesium and sulfates make little difference; surplus iron inhibits growth of rhizoids. The effect upon rhizoids is the resultant between the direct influence upon them and the indirect influence through the thallus. The thallus is smaller and the rhizoids fewer, but usually longer in darkness. Immersed buds show "water-etiolation;" rhizoids in a moist chamber show "air-etiolation;" in solutions poor in nitrates, "etiolation due to nitrogen-hunger." This last idea is supported by experiments of Benecke and others with the rhizoids of *Riccia fluitans* and roots of higher plants.—L. M. SNOW.

CYTOLOGISTS will find in a paper by Häcker[17] an excellent discussion of the individuality of the parental chromatin. After a critical review of the literature, a large part of which has been contributed by himself, the following conclusion is stated: The autonomy of the paternal and maternal halves of the nuclei can be traced in copepods from the fertilized egg through the life cycle to the egg and sperm mother cells. During the maturation of the egg in Cyclops there is a rearrangement of the chromatin elements so that the egg cell contains, in equal measure, elements from the grandfather and grandmother. Connected with this rearrangement is a pairing of the grandfather and grandmother chromosomes. It may be suggested with great probability that this autonomy is of wide, if not general, distribution in plants and animals. The nuclear stages in which the idiomeres (partial nuclei) and gonomeres (double nuclei) appear are closely related. The second part of the paper deals with the nature of fertilization, mixed inheritance, affinity of chromosomes, individuality of the chromosomes and morphological organization of the nucleus, and the determination of sex. The theory that the chromosomes are permanent organs dominates the entire philosophical portion of the paper, and the evidence in favor of this theory is ably presented.—CHARLES J. CHAMBERLAIN.

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[16] BENECKE, W., Ueber die Keimung der Brutknospen von *Lunularia cruciata*. Bot. Zeit. **61**^{1}: 19-46. *figs. 6.* 1903.

[17] HÄCKER, VALENTIN, Ueber das Schicksal der elterlichen und grosselterlichen Kernantheile. Morphologische Beiträge zum Ausbau der Vererbungslehre. Jena. Zeit. Naturwiss. **37**: 297-398. *figs. 16, pls. 1-4.* 1902.

NEWCOMBE[16] has shown conclusively that the so-called thigmotropic responses obtained by Sachs in terrestrial roots were not really such, but merely the effect of injury. The primary roots of seedlings of *Zea mays*, *Pisum sativum*, *Phaseolus vulgaris*, and *Vicia faba* were tested for thigmotropic curvatures with pins, pieces of brass wire, glass needles, and splinters of white oak, yellow and white pine, and tulip wood. None of the species exhibit curvatures with glass or tulip wood and none but Vicia with white pine, but they all curve in the manner described by Sachs when in contact with metal or yellow pine. These observations destroy the only remaining evidence of thigmotropism in terrestrial roots. The phenomenon may be regarded as established, however, for aerial roots. In another paper[17] the same author has shown that in rheotropically curving roots of *Brassica alba*, *Fagopyrum esculentum*, *Helianthus annuus*, and *Zea mays* (white popcorn), the sensory zone extends upward from the tip beyond the region of growth. The same fact was already proved by the same author in case of *Raphanus sativus*.[18] *Brassica alba* shows good rheotropic curves when the root tip is shielded from the water for a distance of 25^{mm}, although the region of growth extends back from the tip only 5 or 6^{mm}. The other roots show similar results.—BURTON E. LIVINGSTON.

GERNECK'S[19] experiments with wheat, oats, maize, and cress in various solutions of single and combined salts yielded the following main results. Of the single solutions, several chlorids, potassium phosphate, and water favor the development of stems rather than leaves, while the reverse is true of nitrates and sodium sulfate. Chlorids of the alkaline earths give stronger plants than those of the alkaline metals. $Ca(NO_3)_2$ produces dwarf plants with very hairy leaves and roots. The fewest hairs appear on plants with the strongest leaves. The most chlorophyll occurs in KNO_3 cultures. With complex solutions wheat can endure the addition of 1.5 per cent., cress 1 per cent. and maize 0.5 per cent. NaCl to the nutrient solution. The addition of

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[18] NEWCOMBE, F. C., Sachs' angebliche thigmotropische Curven an Wurzeln waren traumatisch. Beih. Bot. Centralbl. **12**: 243–247. 1902.

[19] NEWCOMBE, F. C., The sensory zone of roots. Ann. Bot. **16**: 429–447. *fig. 1*. 1902.

[20] ————, The rheotropism of roots. BOT. GAZ. **33**: 177–198, 263–283 341–362. 1902.

[21] GERNECK, RUDOLPH, Ueber die Bedeutung anorganischer Salze für die Entwicklung und den Bau der höheren Pflanzen. Inaugural-Dissertation. pp. 147. Göttingen: W. F. Kaestner. 1902.

NaCl or the dilution of the nutrient solution produces fewer roots and shoots, narrower and shorter leaves with slower development, stronger thickening of the root elements, and a relative increase in the number of bundles. The presence of NaCl is accompanied by the formation of leaves with fewer air-spaces, and more palisade tissue, chlorophyll, and wax. Dilution of the nutrient solution causes an increase in the length of the roots. Nitrogen-free solutions favor the development of stems. The reader observes in the different cultures a variation of osmotic pressure which does not enter into the author's discussion. This of course makes the results at least questionable. —L. M. SNOW.

A HYBRID COTTON obtained by crossing *Gossypium barbadense* and *G. herbaceum* has been studied by Cannon.[22] The investigations deal with the two mitotic divisions by which the microspore mother cell gives rise to the four microspores. In practically all anthers of the hybrid cotton both normal and abnormal conditions are present. In normal microspore mother cells the first nuclear division is heterotypic, the second homotypic; and the two divisions are the exact homologues of these divisions in pure races of plants. The two sizes of the chromatin rings or loops found in hybrid pigeons and in some pure forms in plants were not found in the hybrid cotton. The behavior of the chromatin at the first division could not be traced with sufficient accuracy to determine whether the two daughter nuclei were of pure or of mixed descent. If the paternal and maternal chromatin is segregated as a result of the two mitoses in the microspore mother cell so as to form nuclei with unisexual chromatin, such an organization of the chromatin would form a morphological basis for variation in accord with the Mendelian laws. Many abnormal cells were observed, but these degenerate before the first division of the microspore mother cell. Amitosis is not rare and is probably a factor which leads to infertility. A few mother cells showed two spindles, as described by other writers on hybrids, but in the hybrid cotton such cells degenerate before the first nuclear division is complete.—CHARLES J. CHAMBERLAIN.

A THIRD REPORT on the marine resources of Hokkaido has been published by the Fishery Bureau of the Hokkaido government, Japan. It is devoted to the Laminariaceae and the Laminaria industries of the island and constitutes a volume of 212 pages illustrated by 41 plates. This is a very important contribution to our knowledge of the kelps, but as it is printed in the Japanese language it must remain somewhat inaccessible to most students. The volume contains three papers: (1) on the Laminariaceae of Hokkaido, by Professor Kingo Miyabé; (2) on the Laminaria industries of Hokkaido, by Shin Yanagawa; and (3) chemical analyses of Laminaria, by Professor Kintaro Oshima. In each of these the material is almost altogether original, and the whole constitutes a unique publication of great value. Professor Miyabé considers the outer and inner morphology, propagation, distribution, economic uses, pathology, and classification of the kelps, and describes several new species—eight in Laminaria, three in Alaria, one in Undaria with Dr. Okamura, and establishes a new genus, Kjellmanniella, evidently not very far from Pleurophycus of Setchell and Saunders. Of this two species and one variety are described. The longest of the three articles is the one by Mr. Yanagawa, in which he describes the kelp beds from an economic point of view and discusses the collections, seasons, tools, methods, boats and co-operative agreement among the fishermen. Statistics are given concerning the history of the industry, its total value for the last thirty years, the average annual harvest, the profits of the fishermen, etc. Methods of curing the kelp, prices, government supervision, and a number of other matters of interest are considered, and the trade varieties of kelp are named and described. Professor Kintaro Oshima supplies a brief paper, giving the methods and results of chemical analyses and some notes on organic compounds peculiar to the kelps. The plates are handsome lithographs, quarto size, setting forth the habit of new and important species, figuring the anatomy, and affording views of fishing scenes, tools, warehouses, bales of seaweed and beds of kelp.—CONWAY MACMILLAN.

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[22] CANNON, WILLIAM A., Studies in plant hybrids: The spermatogenesis of hybrid cotton. Bull. Torr. Bot. Club **30**: 133–172. *pls. 7–8.* 1903.

NEWS.

Dr. L. M. Underwood sailed for Europe on the 6th of June. He intends studying in the larger herbaria during the summer.

The gold medal of the Linnean Society for the current year has been conferred upon the veteran British mycologist, Dr. M. C. Cooke.

Mr. Samuel M. Coulter, of the Shaw School of Botany, has been promoted from an instructorship to be assistant professor of botany.

Mr. Howard S. Reed, assistant in plant physiology in the University of Michigan, has been appointed instructor in botany at the University of Missouri.—*Science.*

Lorin Low Dame, a student of the New England flora, especially of the trees of New England, and joint author of several local floras, and an unusually successful director of secondary schools, died on January 27, 1903.

Mr. William R. Maxon, of the U. S. National Museum, has recently returned from a successful collecting tour with Professor L. M. Underwood, in the Blue Mountain region of Jamaica. He has brought with him a fine collection of ferns.

Professor Albert Schneider, of the School of Pharmacy of Northwestern University, has been appointed professor of botany, materia medica, and pharmacognosy in the California College of Pharmacy at San Francisco, a department of the University of California. He will begin his duties in July.

Mr. Gifford Pinchot, chief of the Bureau of Forestry, has been elected to a professorship in the Forest School of Yale University. He will continue his work and his residence in Washington, but by special arrangement will lecture at Yale. Assistant Professor J. W. Toumey has been advanced to a full professorship in the Forest School.—*Science.*

At the annual meeting of the regents of the University of Nebraska on April 24 and 25, Frank G. Miller, of the Yale School of Forestry, was elected professor of forestry, his services to begin September next; Dr. F. E. Clements was promoted from adjunct professor of botany to assistant professor of botany; and H. L. Shantz was appointed an instructor in botany.—*Science.*

We learn from *Gardener's Chronicle* that the new fire-proof herbarium building just outside the Royal Botanical Garden at Kew is completed, and that the plant cases are to be removed at once from the old building while it is being rebuilt and made as nearly fire-proof as possible. The new "wing" is connected with the original building by corridors on each of the three floors. Until the repairs are fully completed there is likely to be some crowding and inconvenience to both staff and visiting botanists.

THE UNIVERSITY OF CALIFORNIA will offer a special course of twenty lectures on forestry this summer, at Idyllwild, in the main pine belt on San Jacinto Mountain, Riverside county. This resort is situated in the midst of a country rich in forest flora, which is immediately available for illustrations. Dr. Willis L. Jepson, of the department of botany, and Professor Arnold V. Stubenrauch, of the department of agriculture, have been detailed to take charge of the work. It is hoped that Mr. Gifford Pinchot, who is in charge of the U. S. Bureau of Forestry, will give some additional lectures on special topics.

HARVARD UNIVERSITY AND NEW YORK UNIVERSITY unite with the Bermuda Natural History Society in inviting botanists and zoologists to spend six weeks in the temporary biological station provided for the present season at Bermuda. The total expense, including transportation from New York and return, and board and lodging for six weeks at Bermuda, will be $100. The Bermuda Natural History Society has undertaken to provide facilities for collecting, namely, a steam launch, with crew; a sail boat with fish-well and crew; three row boats; and a two-horse carriage capable of carrying ten or twelve persons. The laboratory will be equipped with necessary reagents and utensils except microscopes and dissecting instruments, which should be brought by each investigator. There are two possible dates of sailing from New York: June 20 and July 4. The laboratory will be opened for those who sail on June 20 and will remain open eight weeks, thus providing for those who cannot sail until July 4. Circulars and detailed information will be supplied on application either to Professor C. L. Bristol, University Heights, New York city, or to Professor E. L. Mark, 109 Irving street, Cambridge, Mass.

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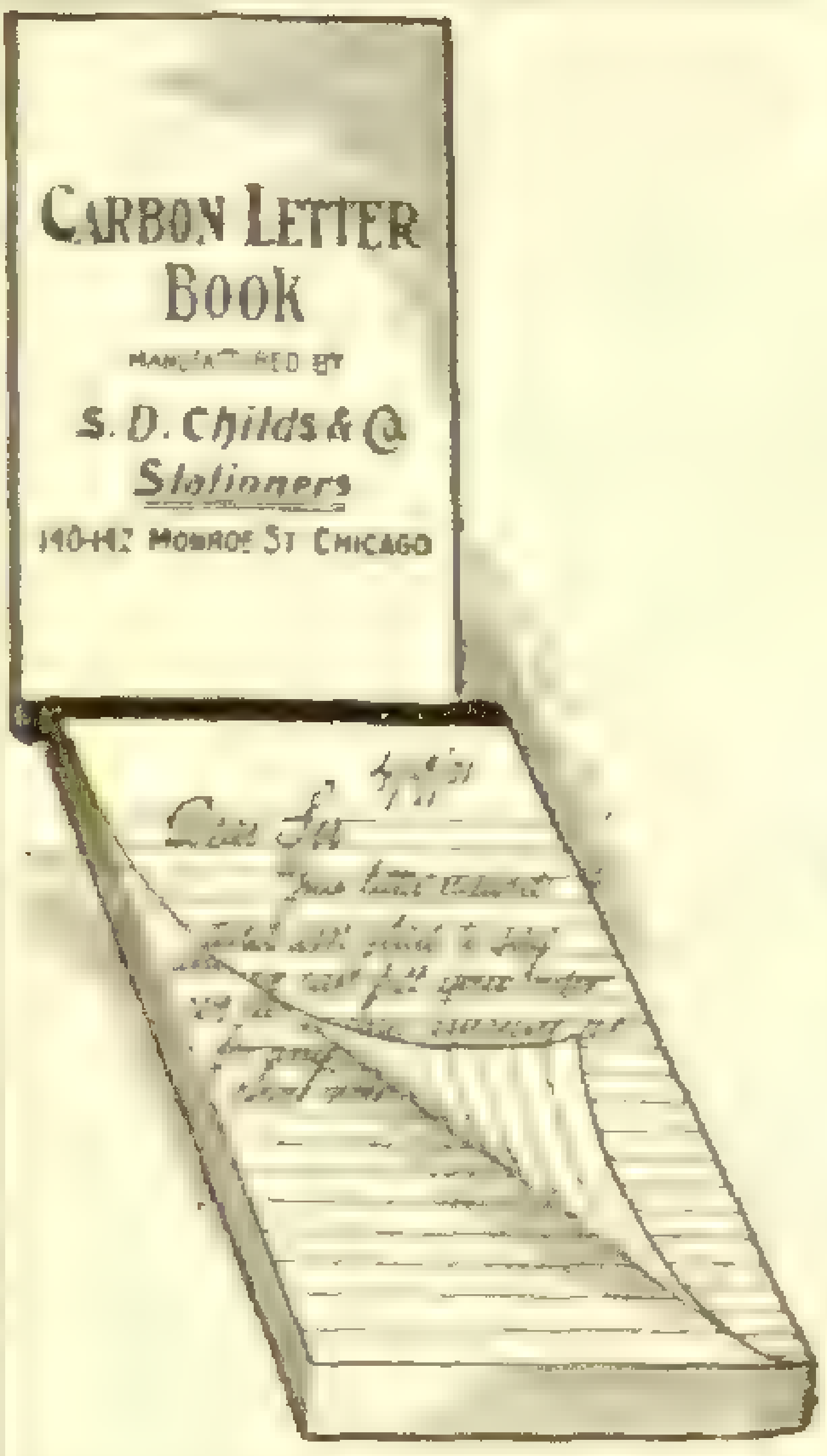
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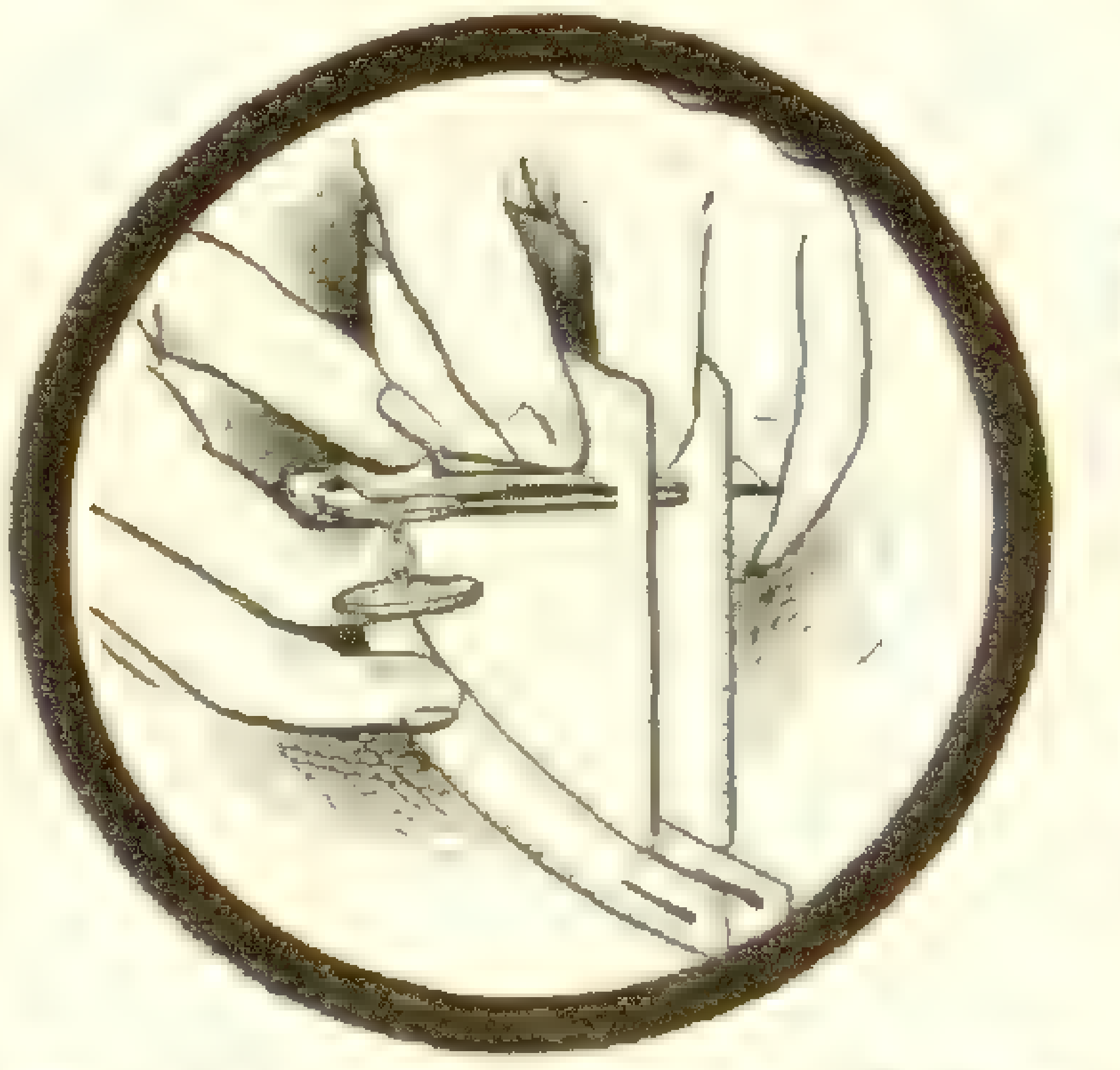

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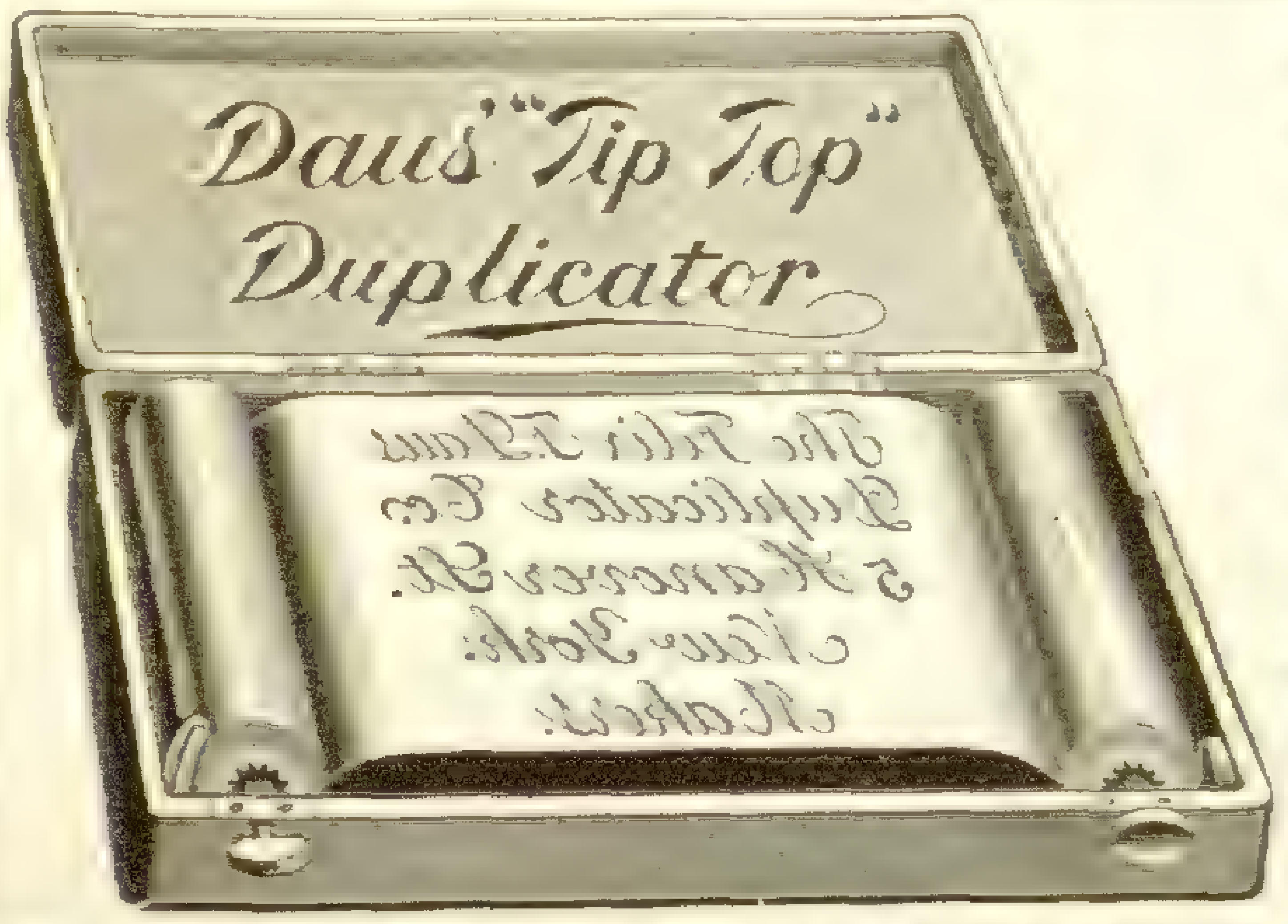
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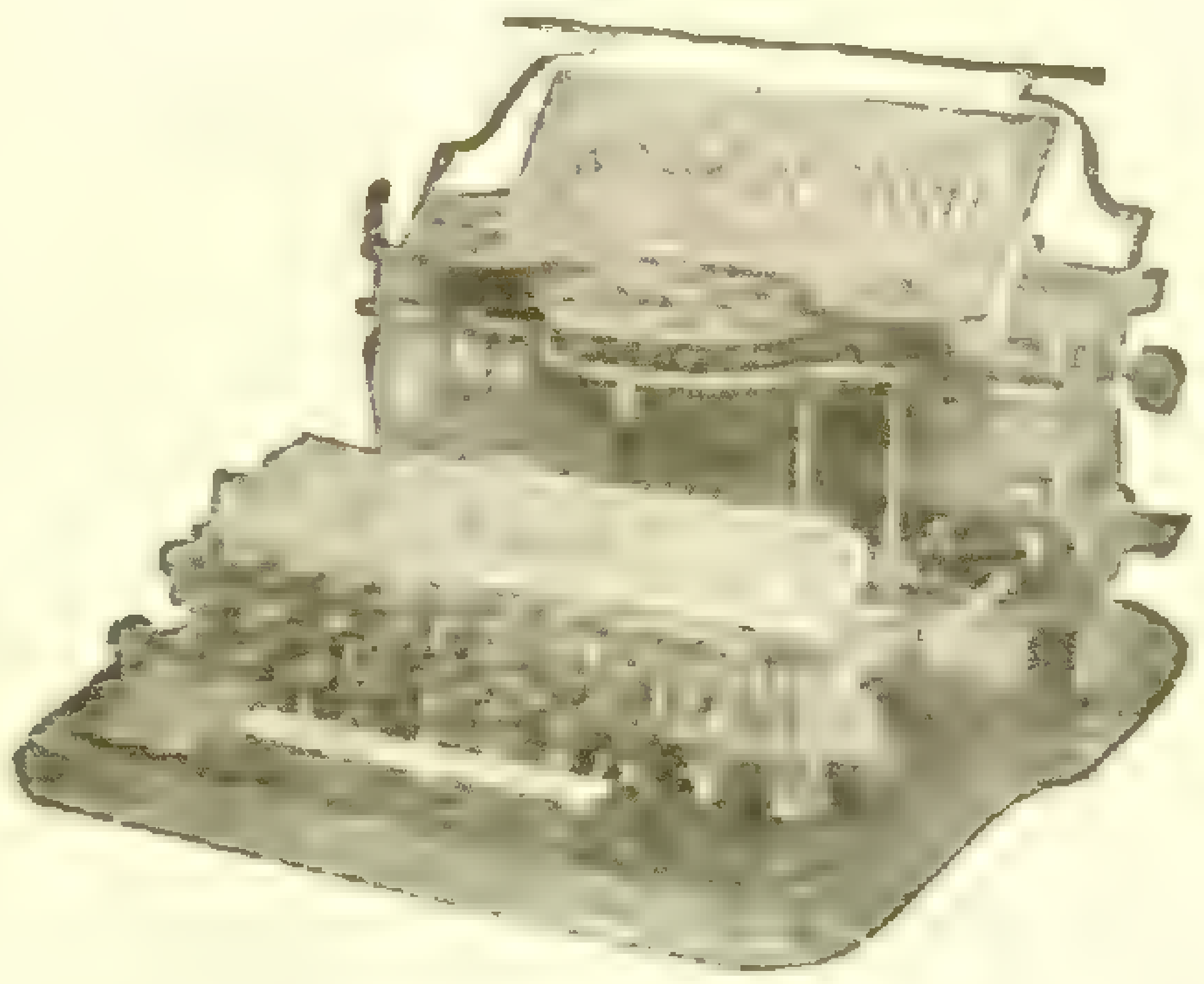

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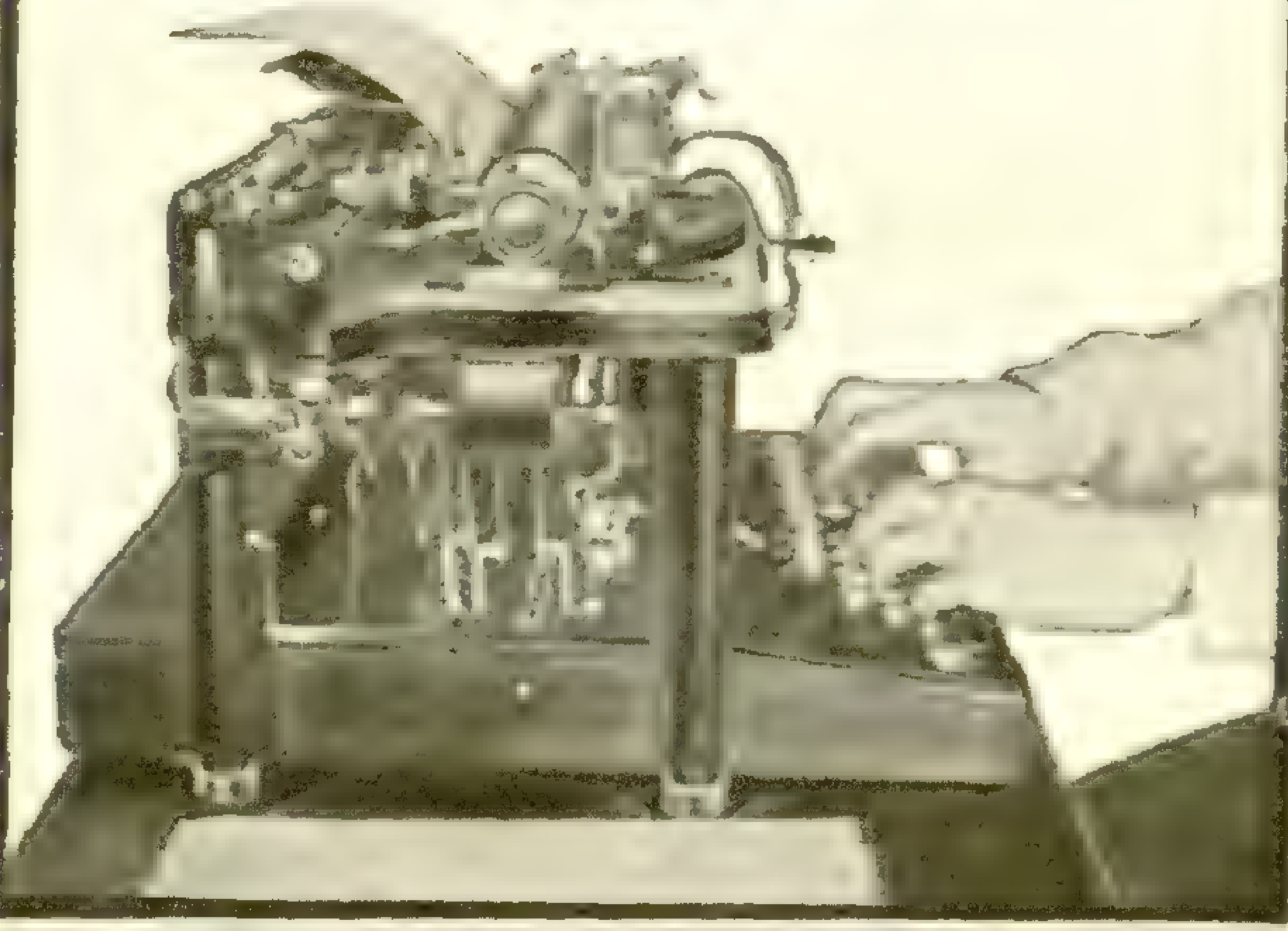

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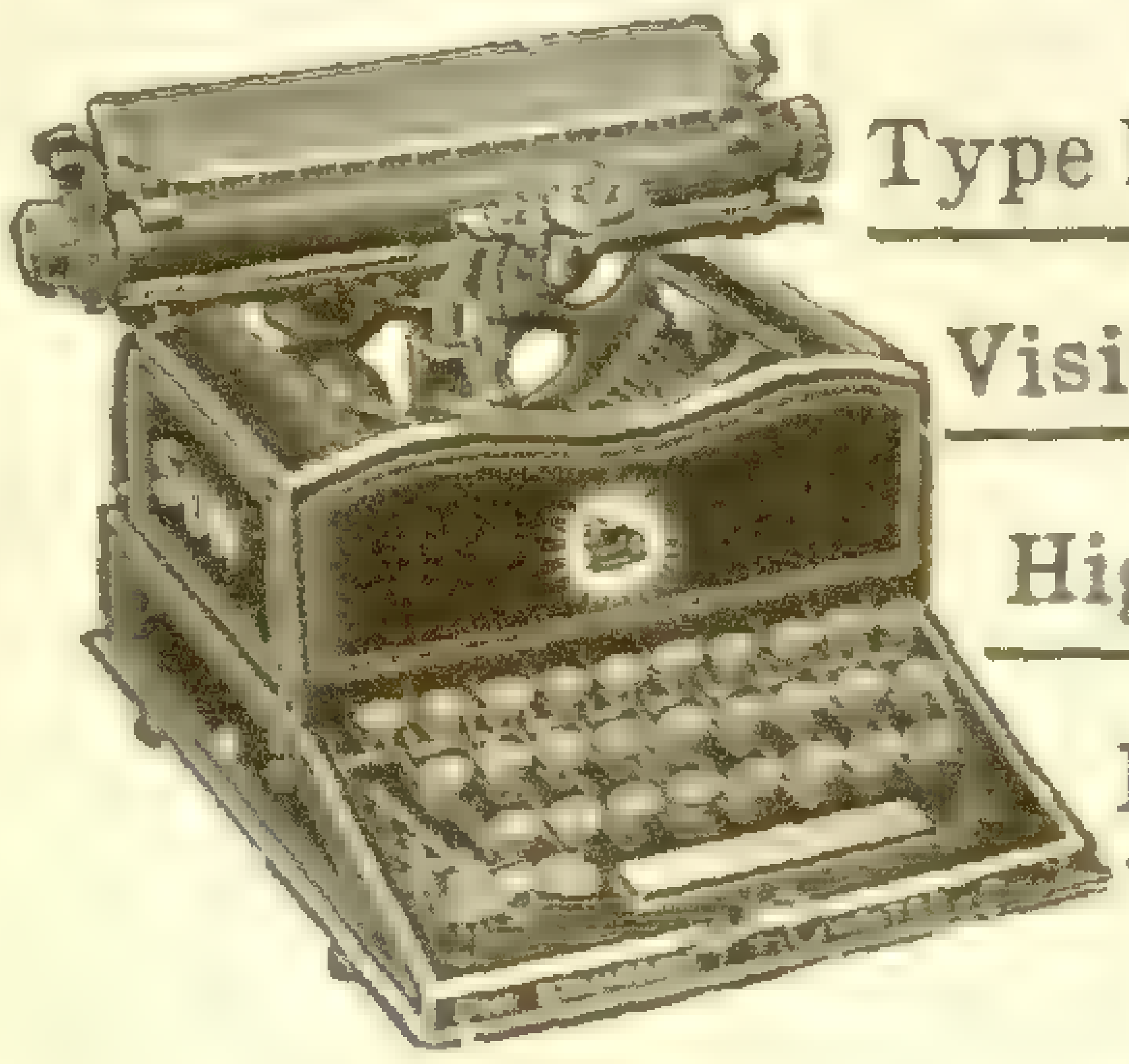

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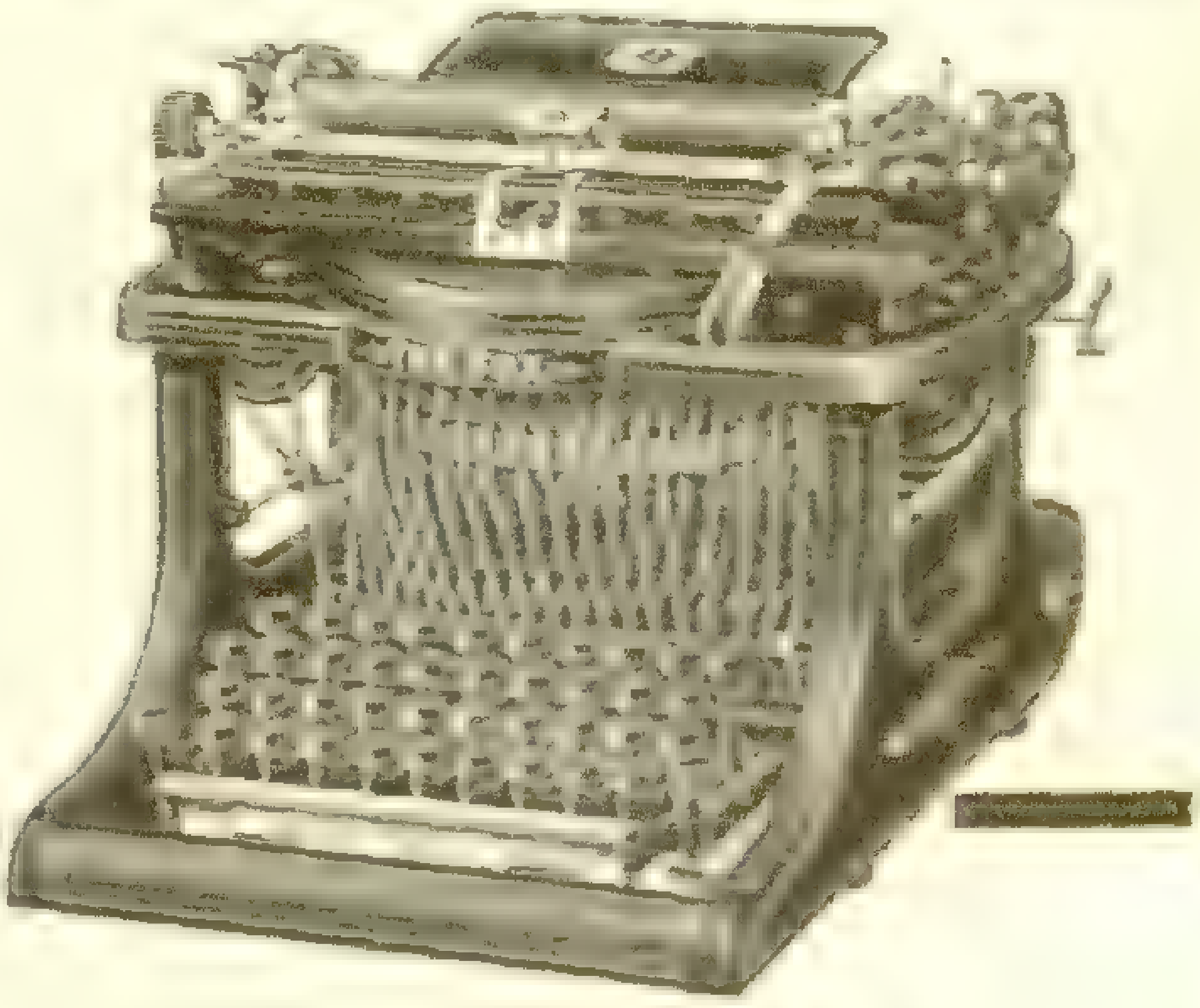

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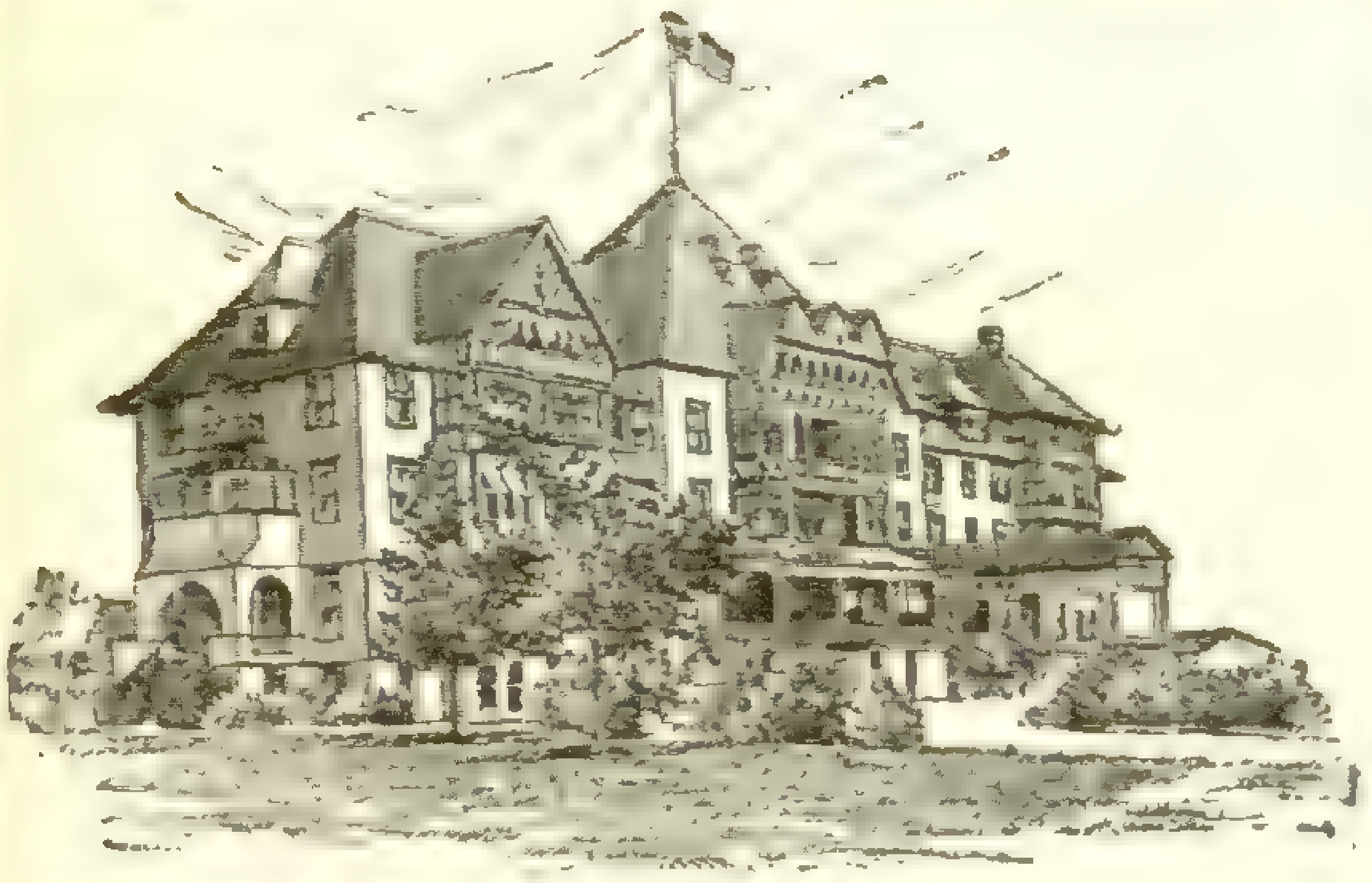

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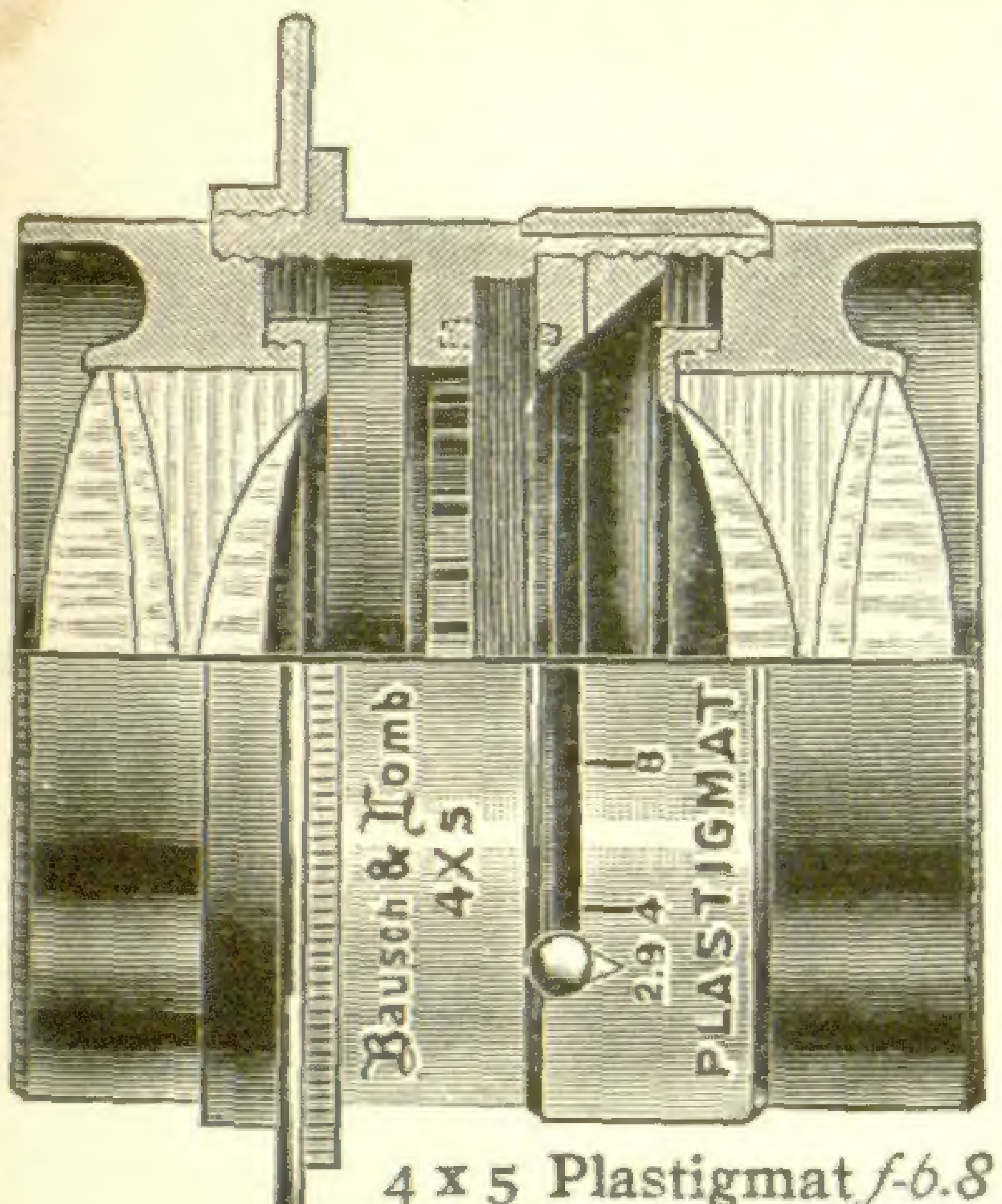

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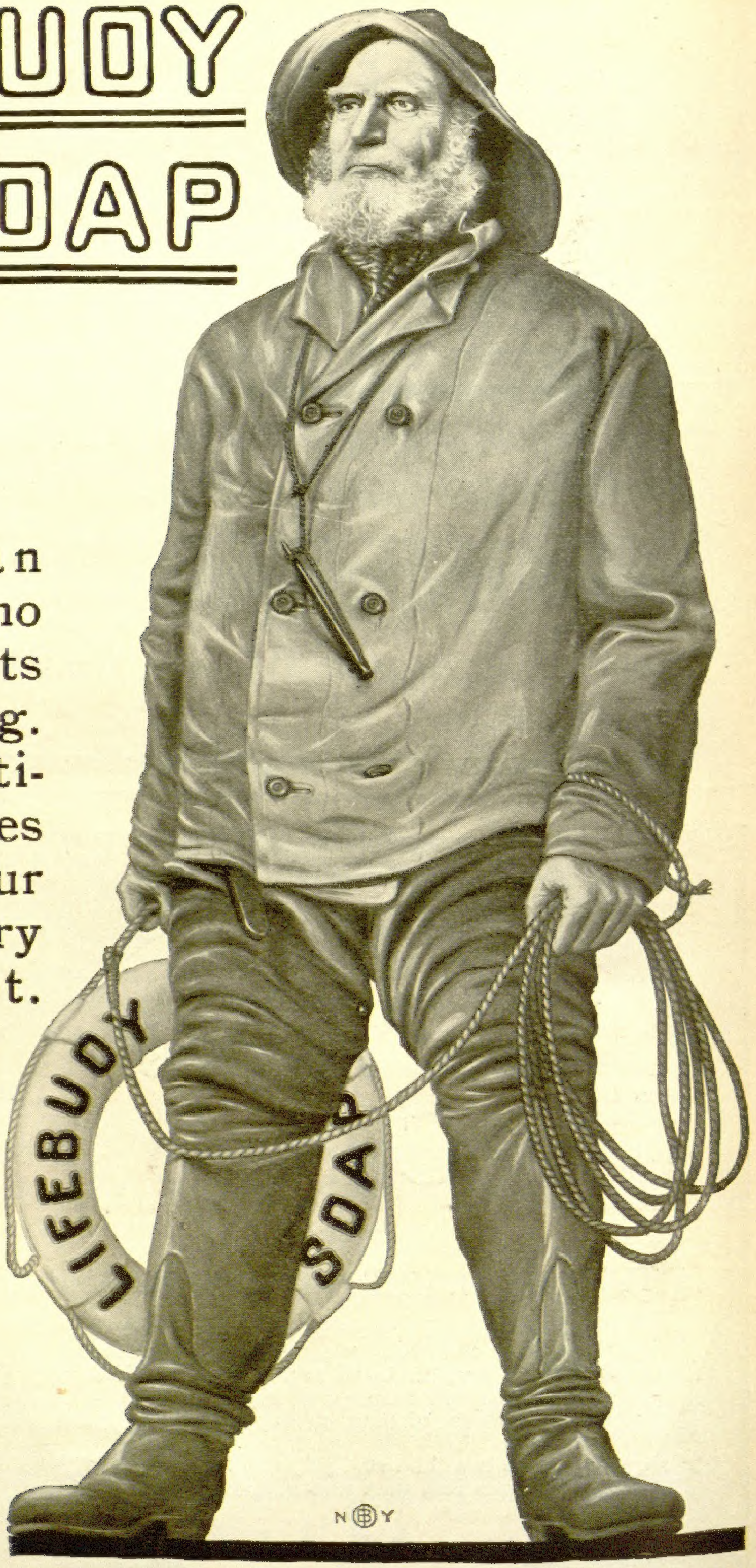

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